Marine Litter :
are there solutions to this global environmental problem?

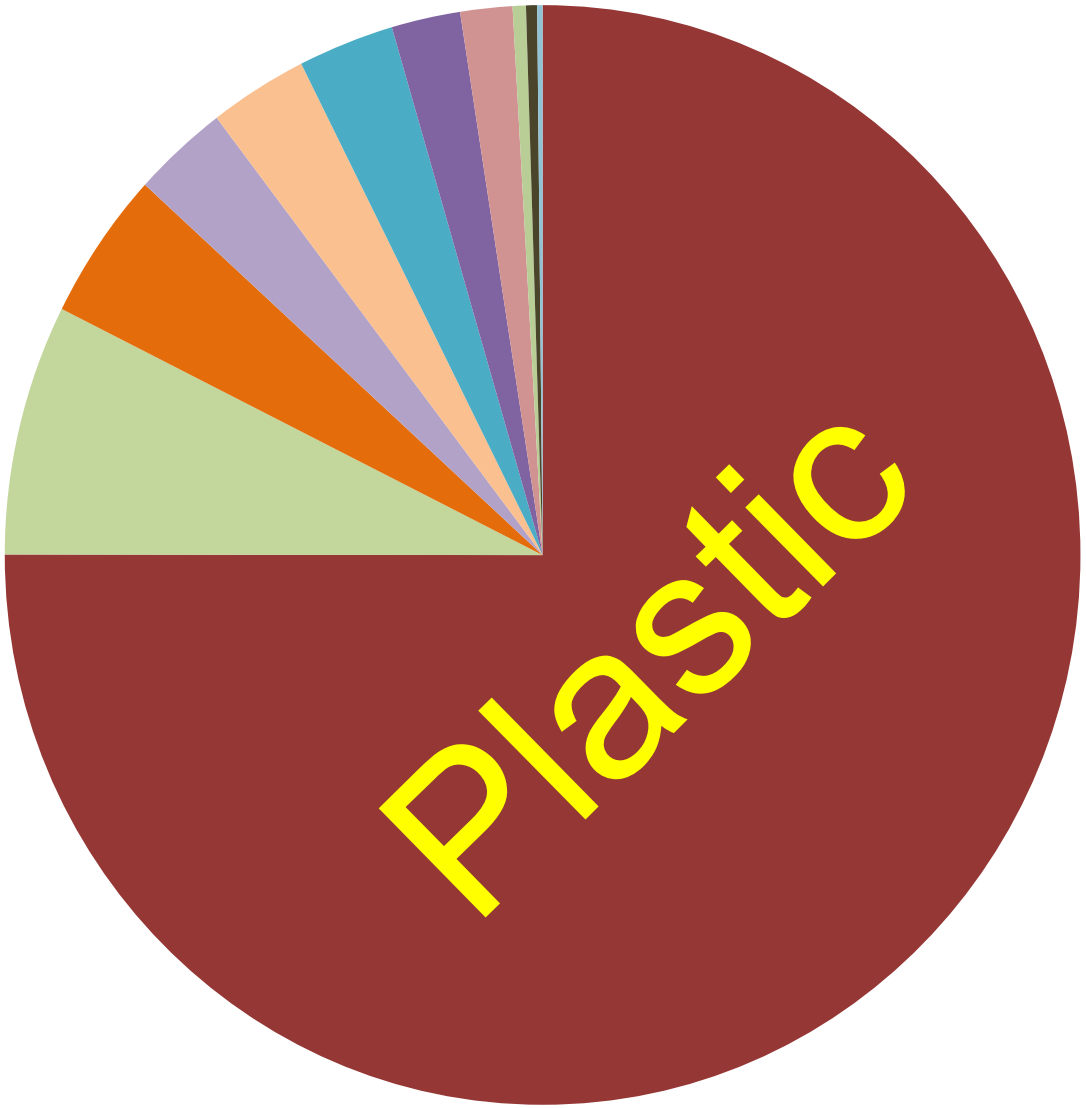
Richard Thompson, Plymouth University, UK

Image credit B. Frymire


Slovenia


Mediterranean Sea, 1000m
F. Galgani

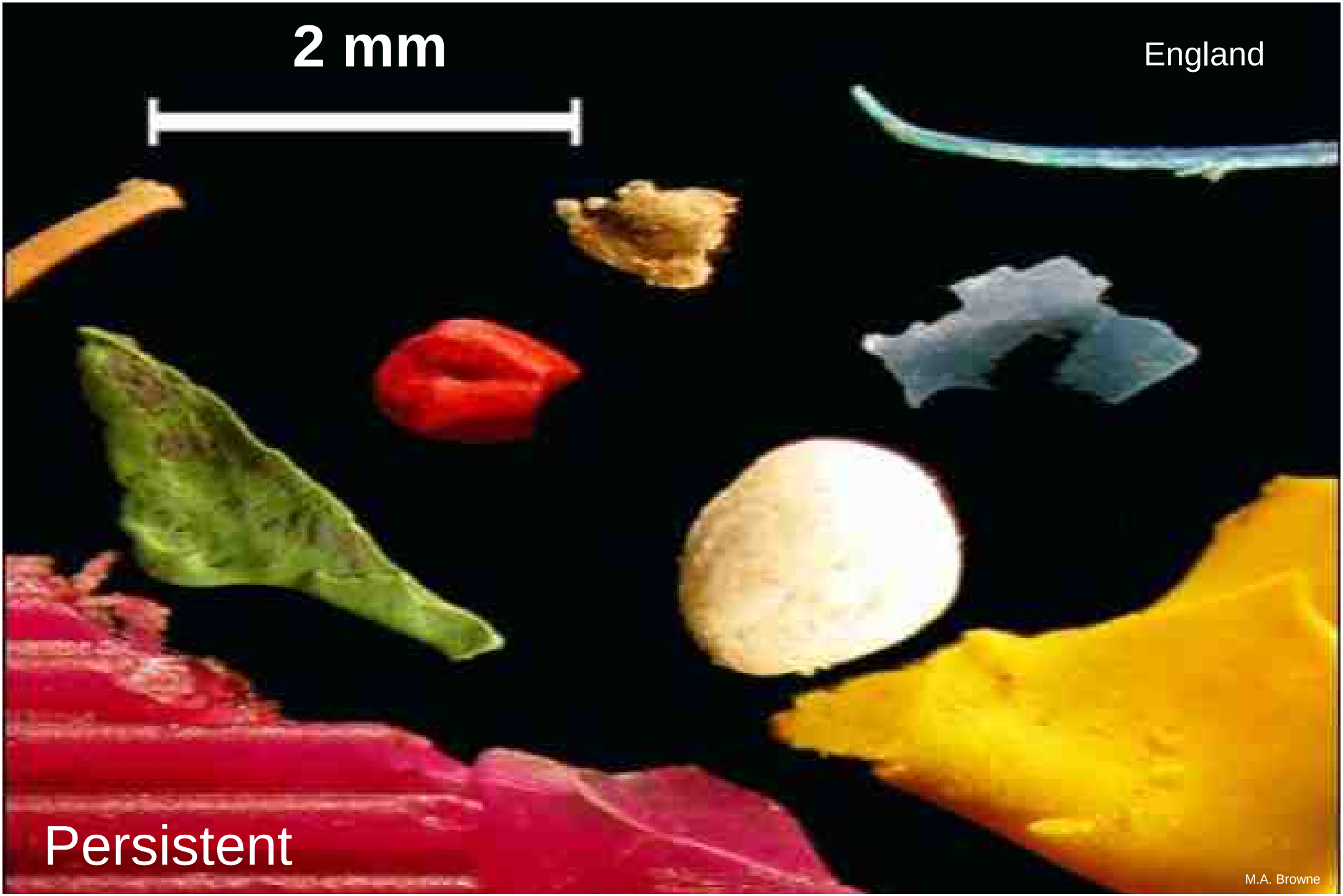
Mostly plastic



- Plastic & Polystyrene
- Sanitary
- Paper & Cardboard
- Wood
- Cloth
- Metal
- Glass
- Rubber
- Pottery & Ceramics
- Faeces
- Medical

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


R. C. Thompson


2 mm
England
Persistent
M.A. Browne

Plastic litter widespread and accumulating

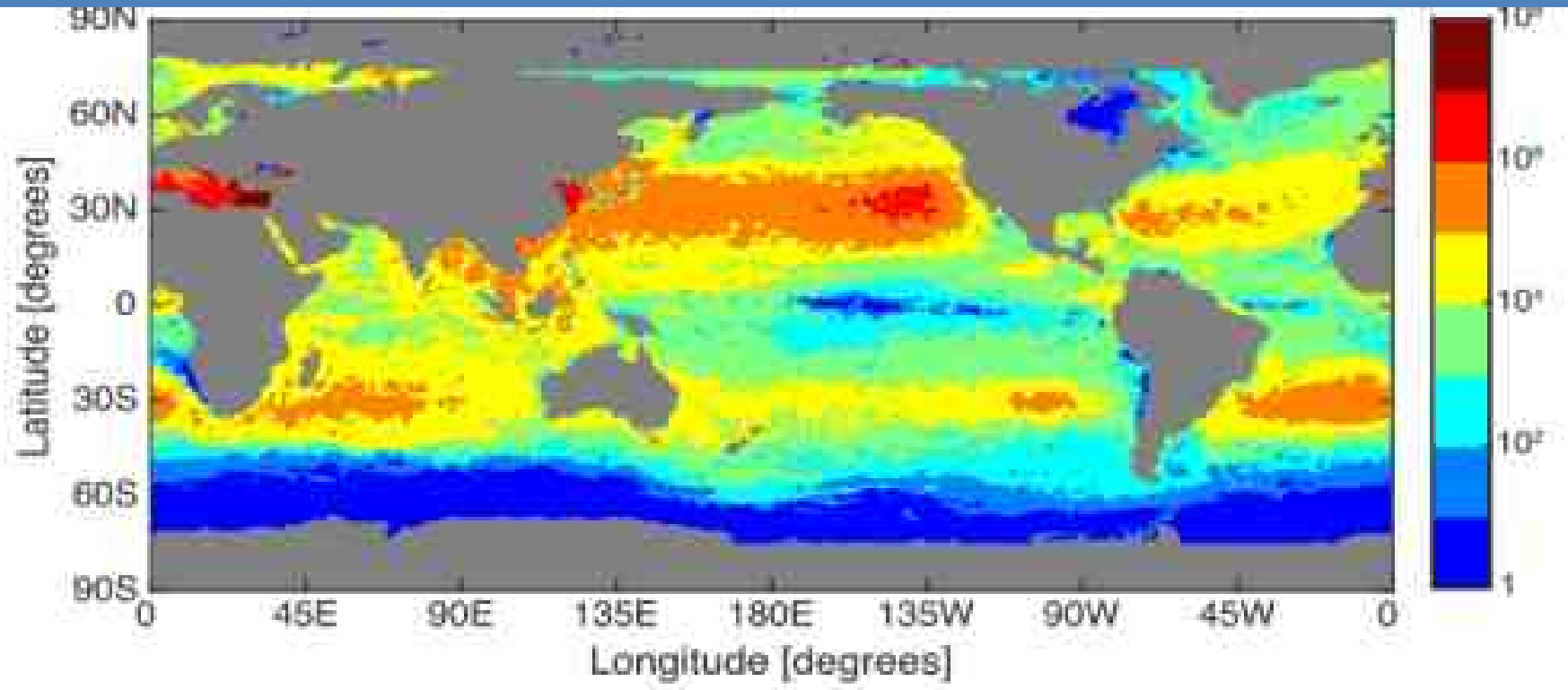
Environmental Research Letters

LETTER

OPEN ACCESS

A global inventory of small floating plastic debris

Erik van Sebille, Chris Wilcox, Laurent Lebreton, Nikolai Maximenko, Britta Denise Hardesty, Jan A van Franeker, Marcus Eriksen, David Siegel, Francois Galgani and Kara Lavender Law



Economic consequences

England

Effects on human wellbeing?

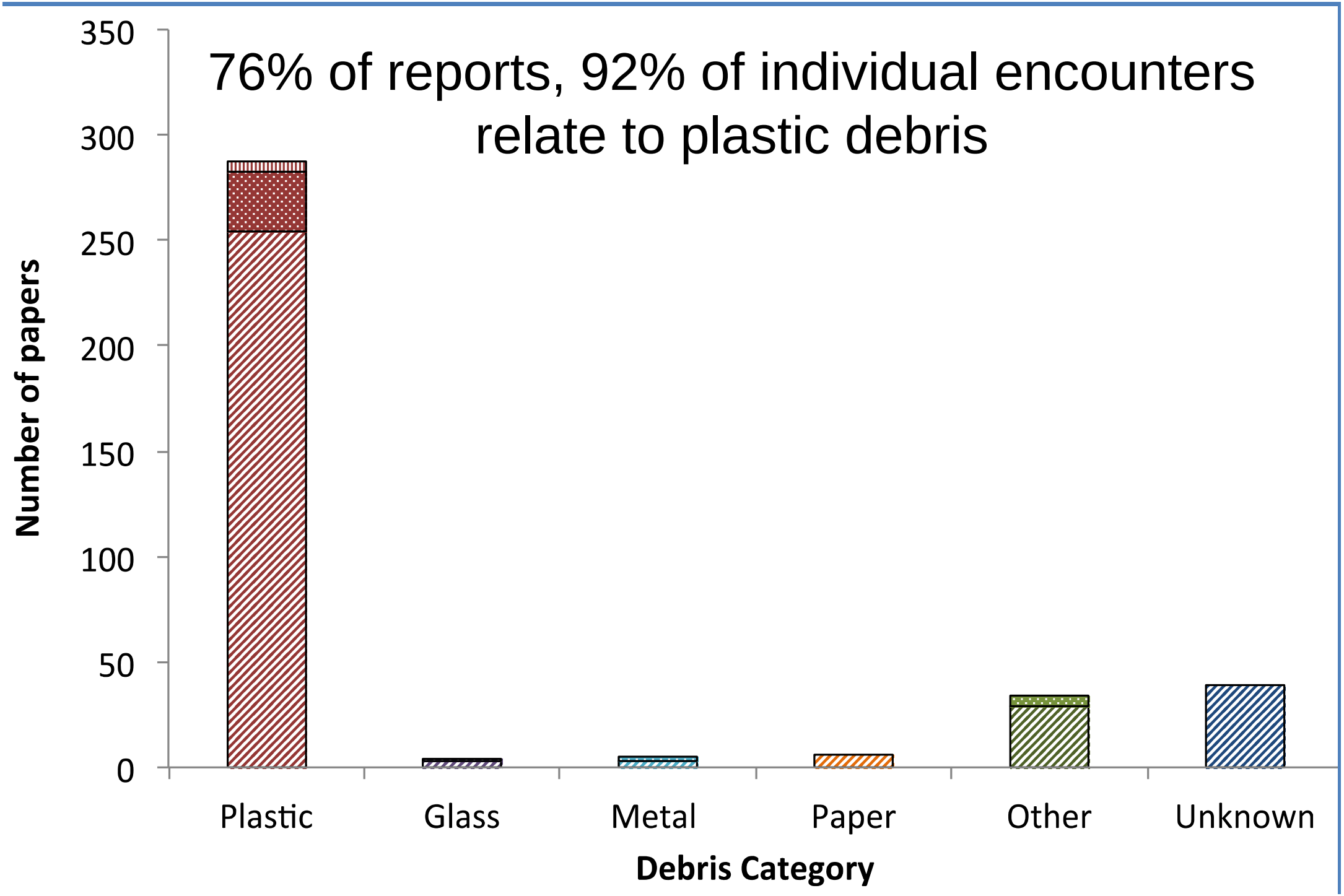
Wyles, Pahl and Thompson 2015

Hazard to mariners

Consequences for wildlife

~ 700 Species

17 % threatened
or near threatened
IUCN status

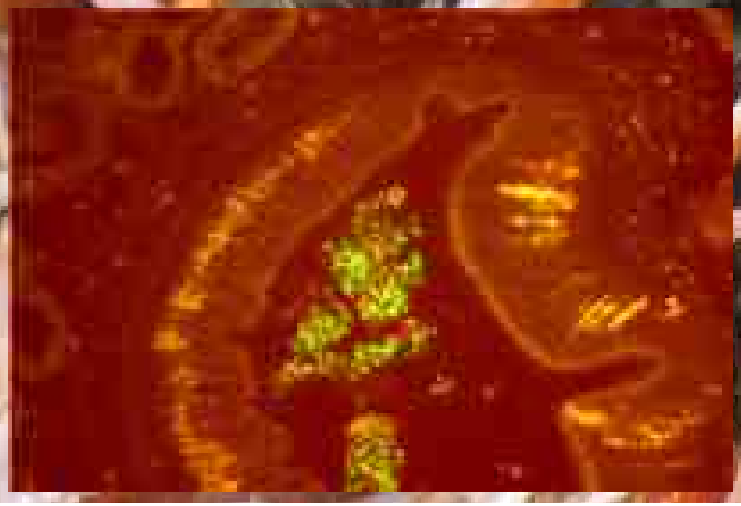

76% of reports, 92% of individual encounters relate to plastic debris
Number of papers
350
300
250
200
150
100
50
0
Plastic
Glass
Metal
Paper
Other
Unknown
Debris Category

Sea birds:
21% of species ‘entangled’
38% of species ‘ingest’

Northern Fulmar
95% of population
contain ingested debris

Key research: van Franeker IMARES

Microplastics: numerous species ingest some retain, ~ 10% of published reports



Key research: Thompson / Browne / Murray /Cowie

Microplastics – concern about transfer of chemicals

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

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

New York Times 30/10/07

Haul aboard

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

sea of rubbish – dubbed the gre
bage patch, and which may contain
tonnes of flotsam – swirls around in a
tem of currents known as the North Pa
Gyre, a large amount of microplastic w
expected; indeed, the highest concentr
tions were found there. But Esperanza als
discovered an unexpectedly high number
of particles in the Atlantic, around the
Canary Islands and the Azores. The haul
of microplastic continued in the Mediter-
ranean, 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.

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.

Western Morning News 13/12/06

Environ. Sci. Technol. 2001, 35, 318–324

Plastic Resin Pellets as a Transport Medium for Toxic Chemicals in the Marine Environment

YUKIE MATO,† TOMOHIKO ISOBE,‡ HIDESHIGE TAKADA,*,† HARUYUKI KANEHIRO,§ CHITOKO OHTAKE,§ AND TSUGUCHIKA KAMINUMA§

Faculty of Agriculture, Tokyo University of Agriculture & Technology, Fuchu, Tokyo 183-8509, Japan, Tokyo University of Fisheries, Minatoku, Tokyo 108-8477, Japan, and Division of Chemi-file Information, National Institute of Health Sciences, 1-18-1 Kamiyoga Setagaya-ku, Tokyo 158-8501, Japan

both during manufacturing and transport. The released resin pellets are carried by surface runoff, streams, and river waters eventually to the ocean. Resin pellets can also be directly introduced to the ocean through accidental spills during shipping. Because of their environmental persistence, they are distributed widely in the ocean and found on beaches and on water surfaces all over the world (*1*–*6*). A growing production of plastic leads to a measurable increase in plastic pollution in the ocean. A significant increase in concentrations of plastic particles, including resin pellets, in the sea-surface has been observed in the North Pacific from the 1970s to the late 1980s (*4*, *7*).

Some studies in 1970s reported that marine plastic resin pellets contain polychlorinated biphenyls (PCBs) (*7*, *8*). They were either adsorbed from ambient seawater or came from plasticizers used until the 1970s in most countries, although neither hypothesis has been proven conclusively. Many species of marine organisms (e.g., seabirds) accumulate large numbers of plastic particles in their stomachs (*9*–*16*). It is

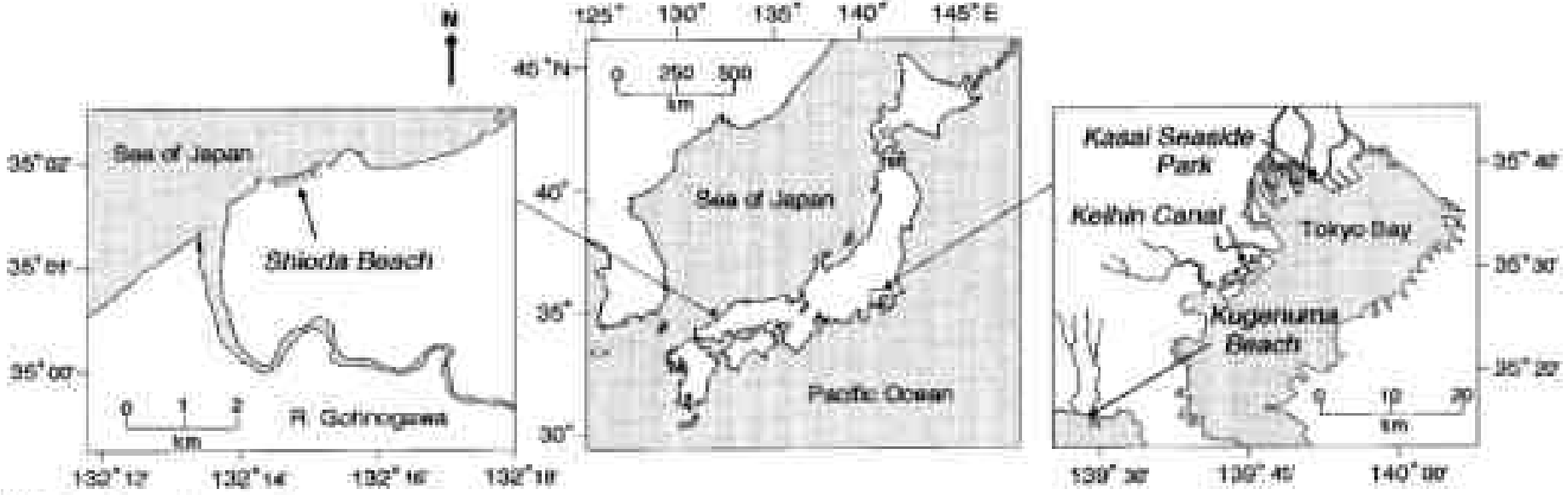


FIGURE 1. Sampling locations.

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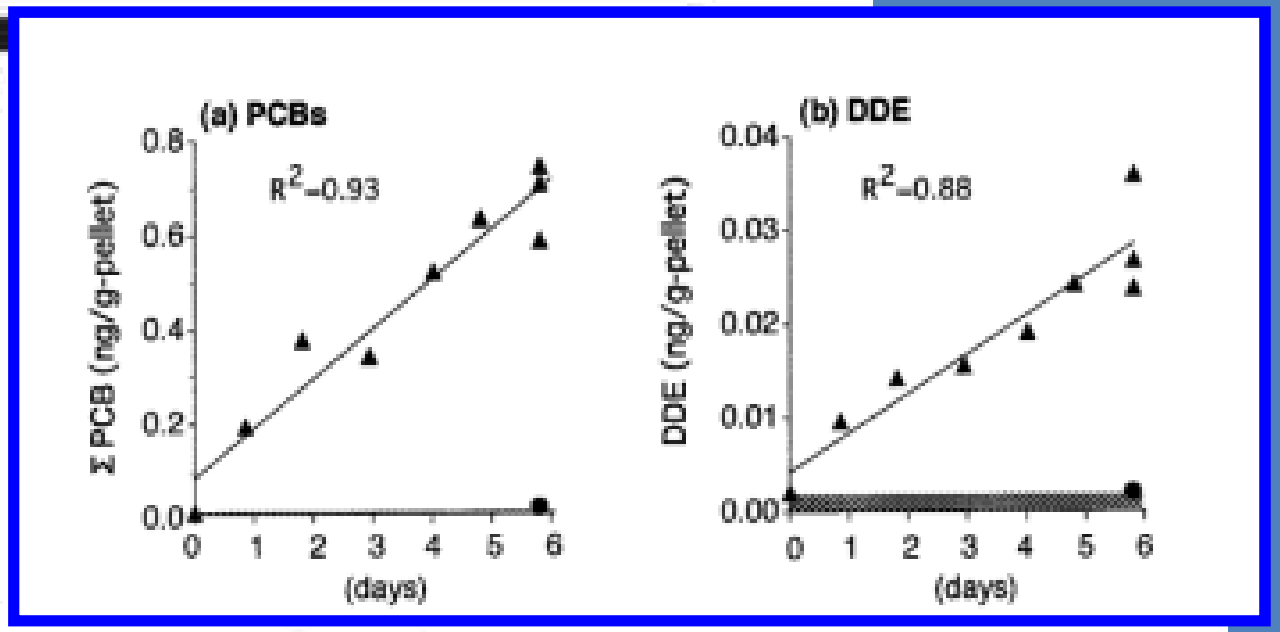


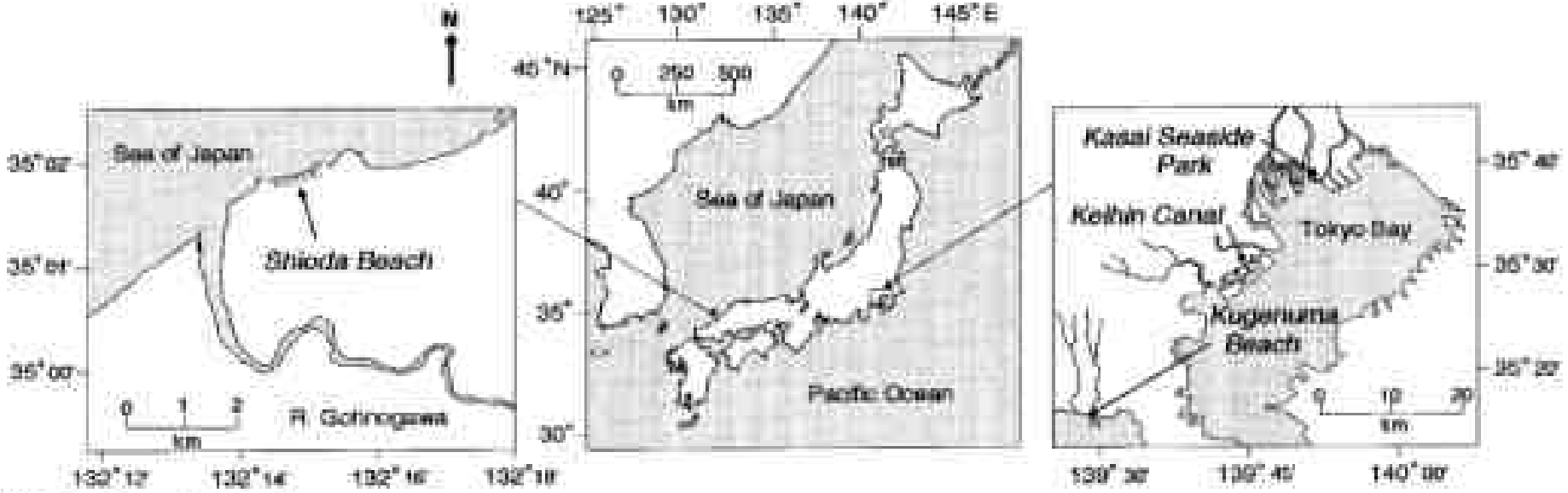


FIGURE 1. Sampling locations.

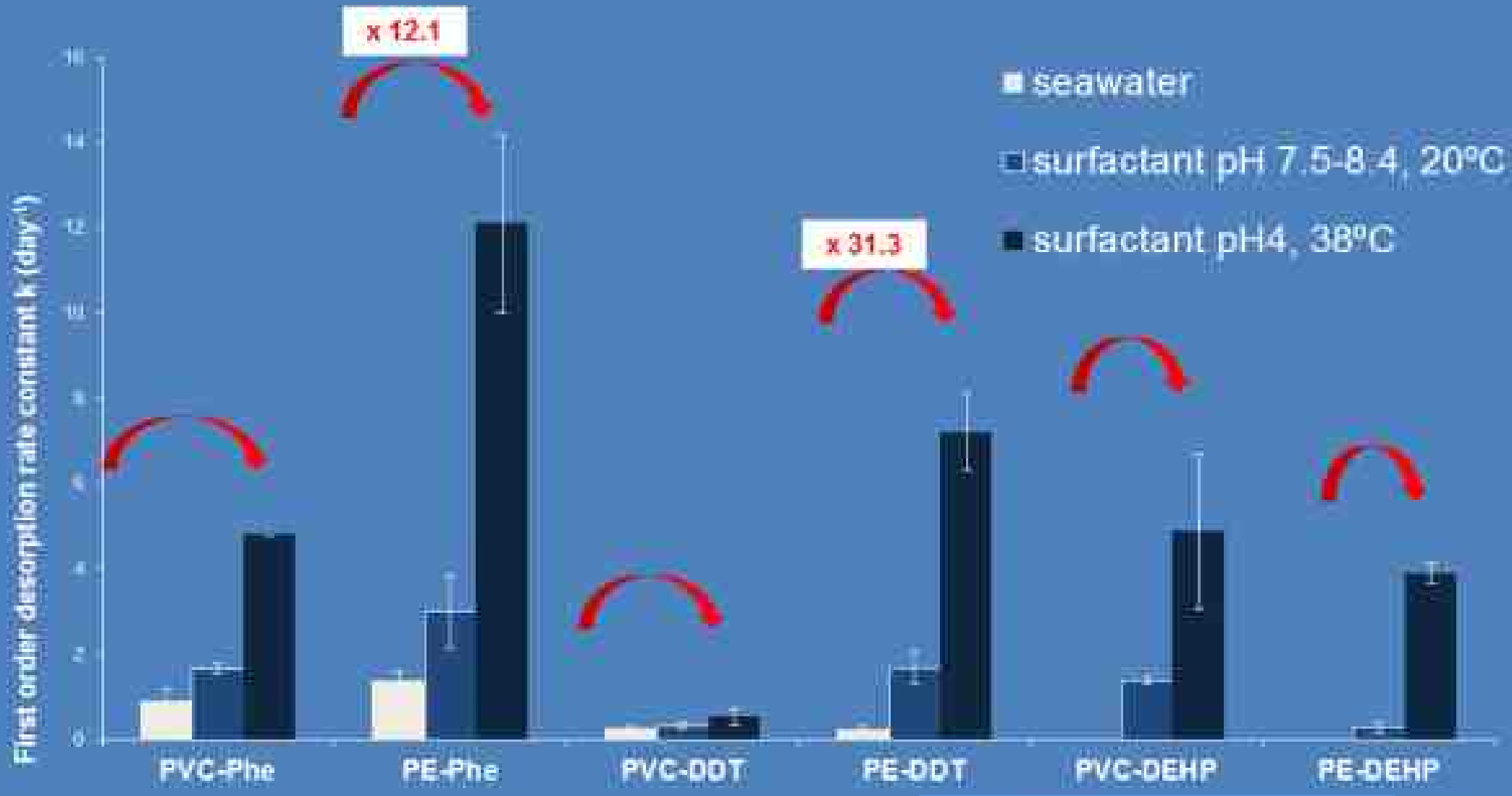
Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

International Pellet Watch: Global monitoring of persistent organic pollutants (POPs) in coastal waters. 1. Initial phase data on PCBs, DDTs, and HCHs

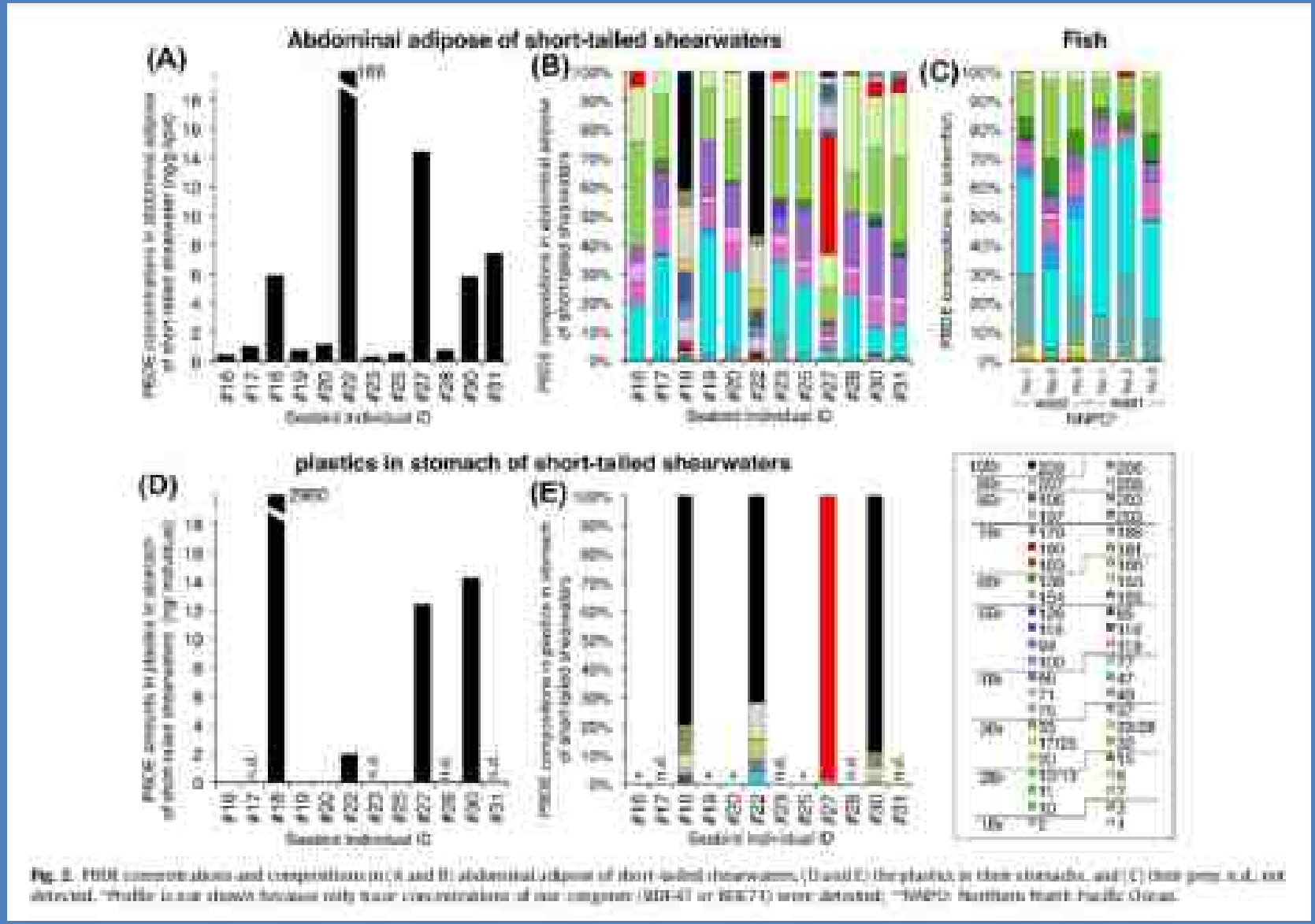
Yuko Ogata[a], Hideshige Takada[a,*], Kaoruko Mizukawa[a], Hisashi Hirai[a], Satoru Iwasa[a], Satoshi Endo[a], Yukie Mato[a], Mahua Saha[a], Keiji Okuda[a], Arisa Ruchaya Booyatumanondo[a], Muhamad Pauzi Za[a], Satoru Suzuki[b], Charles Moore[c], Hiroshi K. Karapa[d], Wulfe Smith[e], Michael Van Velkenburg[e], Judith

Rate of release of POPs increases in gut conditions



Bakir *et all.,* Environmental Pollution, 2014

Uptake of additive chemicals by birds



Tankaka *et al.* (2013) Marine Pollution Bulletin

Facilitated Leaching of Additive-Derived PBDEs from Plastic by Seabirds' Stomach Oil and Accumulation in Tissues

Kosuke Tanaka[†], Hideshige Takada*[†], Rei Yamashita[†], Kaoruko Mizukawa[†], Masa-aki Fukuwaka[‡], and Yutaka Watanuki[§]

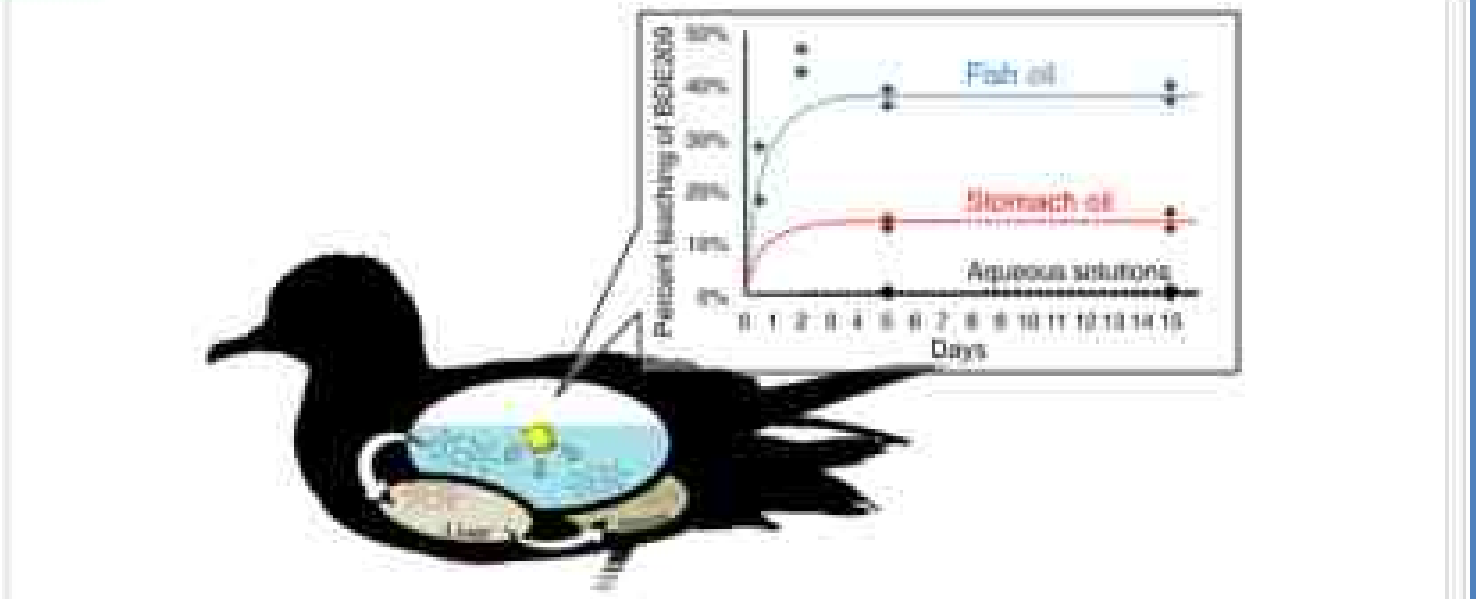
[†] Laboratory of Organic Geochemistry, Tokyo University of Agriculture and Technology, Fuchu, Tokyo 183-8509, Japan
[‡] Hokkaido National Fisheries Research Institute, Fisheries Research Agency, Kushiro, Hokkaido 085-0802, Japan
[§] Faculty of Fisheries, Hokkaido University, Hakodate, Hokkaido 041-8611, Japan

Environ. Sci. Technol., **2015**, 49 (19), pp 11799–11807
DOI: 10.1021/acs.est.5b01376
Publication Date (Web): September 1, 2015

*E-mail: hideshige@cc.tuat.ac.jp

ENVIRONMENTAL Science & Technology

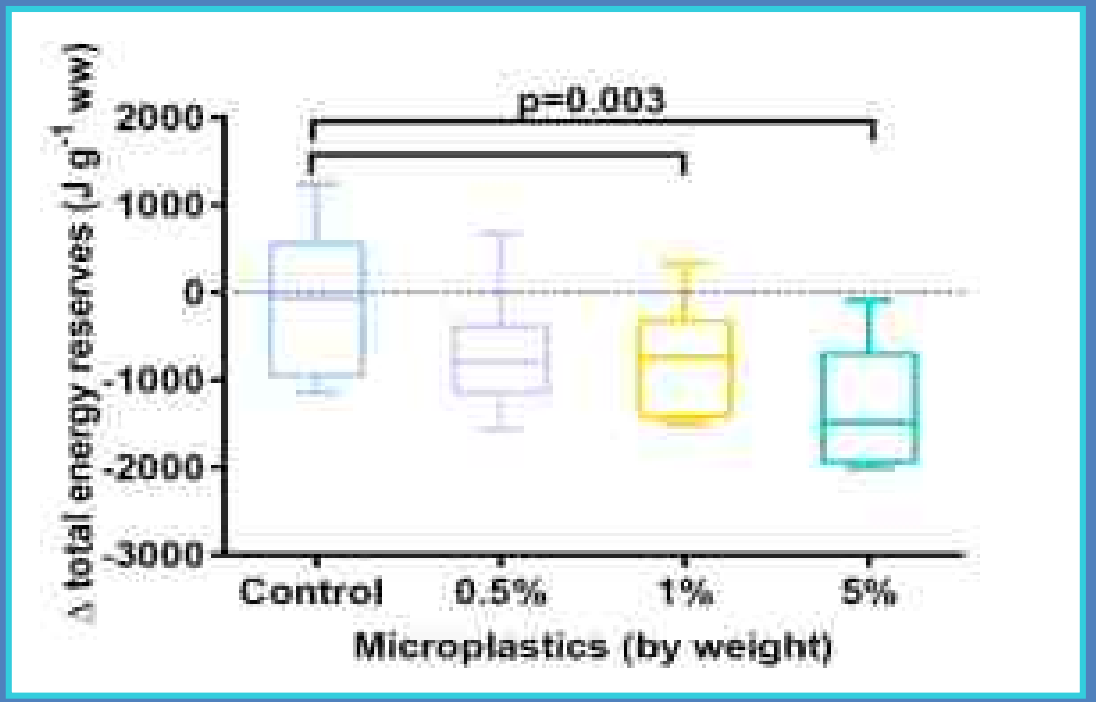
Abstract



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) Current Biology

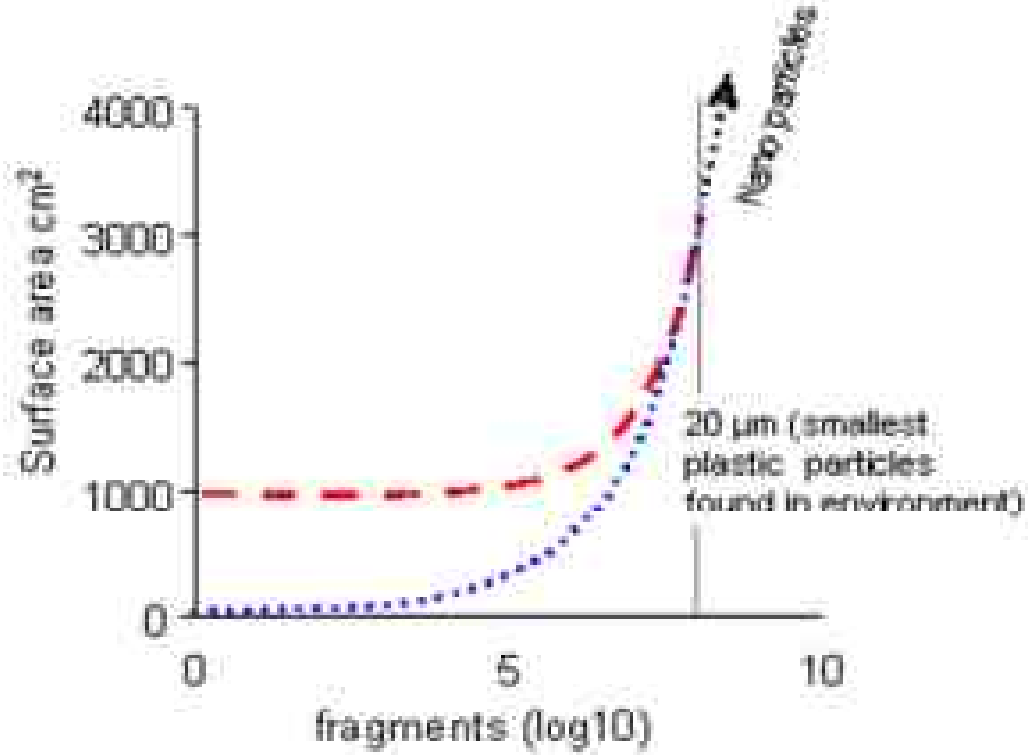
Quantity of microplastic in the ocean will increase

A Plastic packaging

Plastic carrier bag

Plastic canister

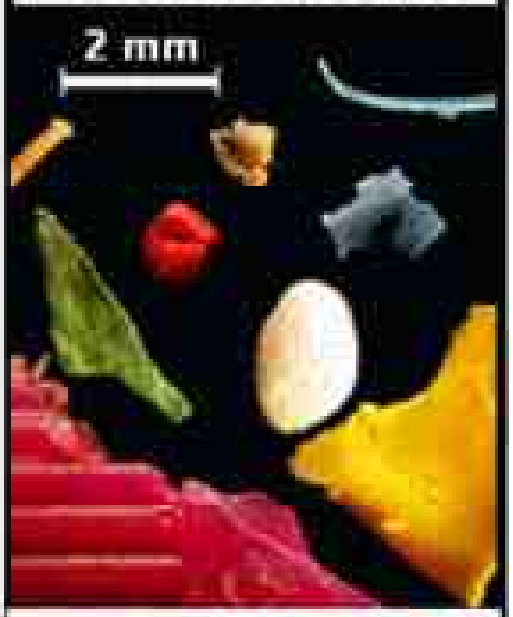
B Fragmentation of plastic items in the environment

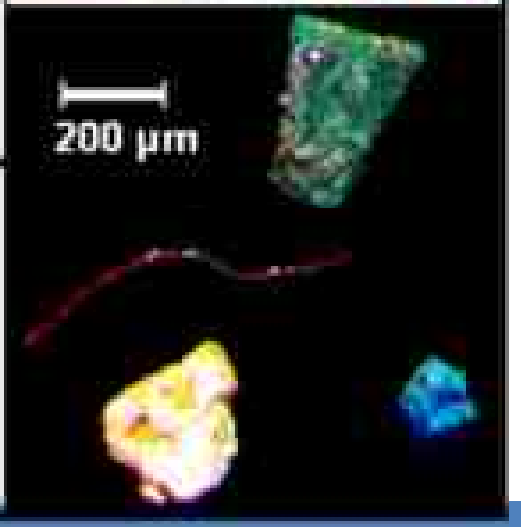


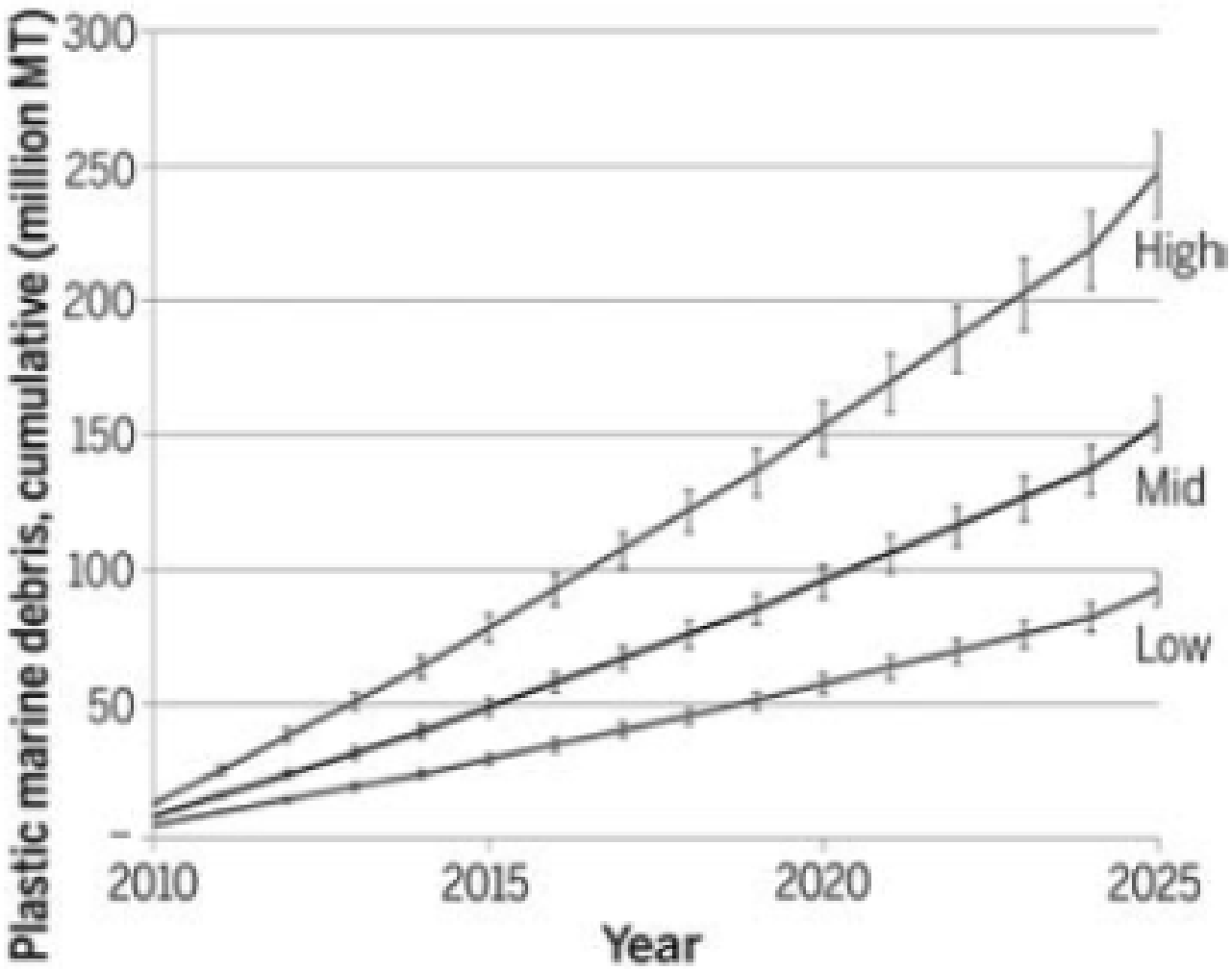
C Consequences of fragmentation

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

D plastic fragments from the shoreline







Plastic debris cumulative

Oceans could contain 250 million tonnes by 2025

Jambeck *et al.* 2015

Fig. 2. Estimated mass of mismanaged plastic waste (millions of metric tons) input to the ocean by populations living within 50 km of a coast in 192 countries, plotted as a cumulative sum from 2010 to 2025. Estimates reflect assumed conversion rates of mismanaged plastic waste to marine debris (high, 40%; mid, 25%; low, 15%). Error bars were generated using mean and standard error from the predictive models for mismanaged waste fraction and percent plastic in the waste stream (12).


Enough about problems
what can be done?


Source, Tanya’s Travel

Keep the benefits – without the debris

60 years of research and development
60 years of behavioural training - to throw away

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

Sources of debris

Around 50% is single-use items (plastic packaging, convenience)

Together with Rope and netting, Cigarette buts

Redirect the flow

Block the holes

Clean-up

Photo sources:
Success hacker, jschneid,

Redirect the flow

Block the holes

Clean-up

Redirect the flow

Block the holes

Clean-up

Redirect the flow

Block the holes

Clean-up

Conflicting drivers

Redirect the flow

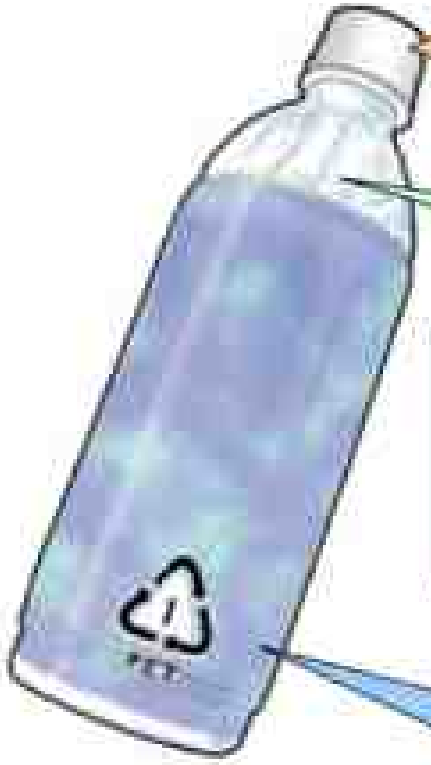
Block the holes

Clean-up

5. 3R (Reduce, Reuse, Recycle) in Japan

PET
CPBR,J

Voluntary Design Guideline for Designated PET bottles
= Obligation of PET Bottle Manufacturers & Users



Plastic Closures must be made of PE or PP.
Do not use Aluminum Closures.

PET

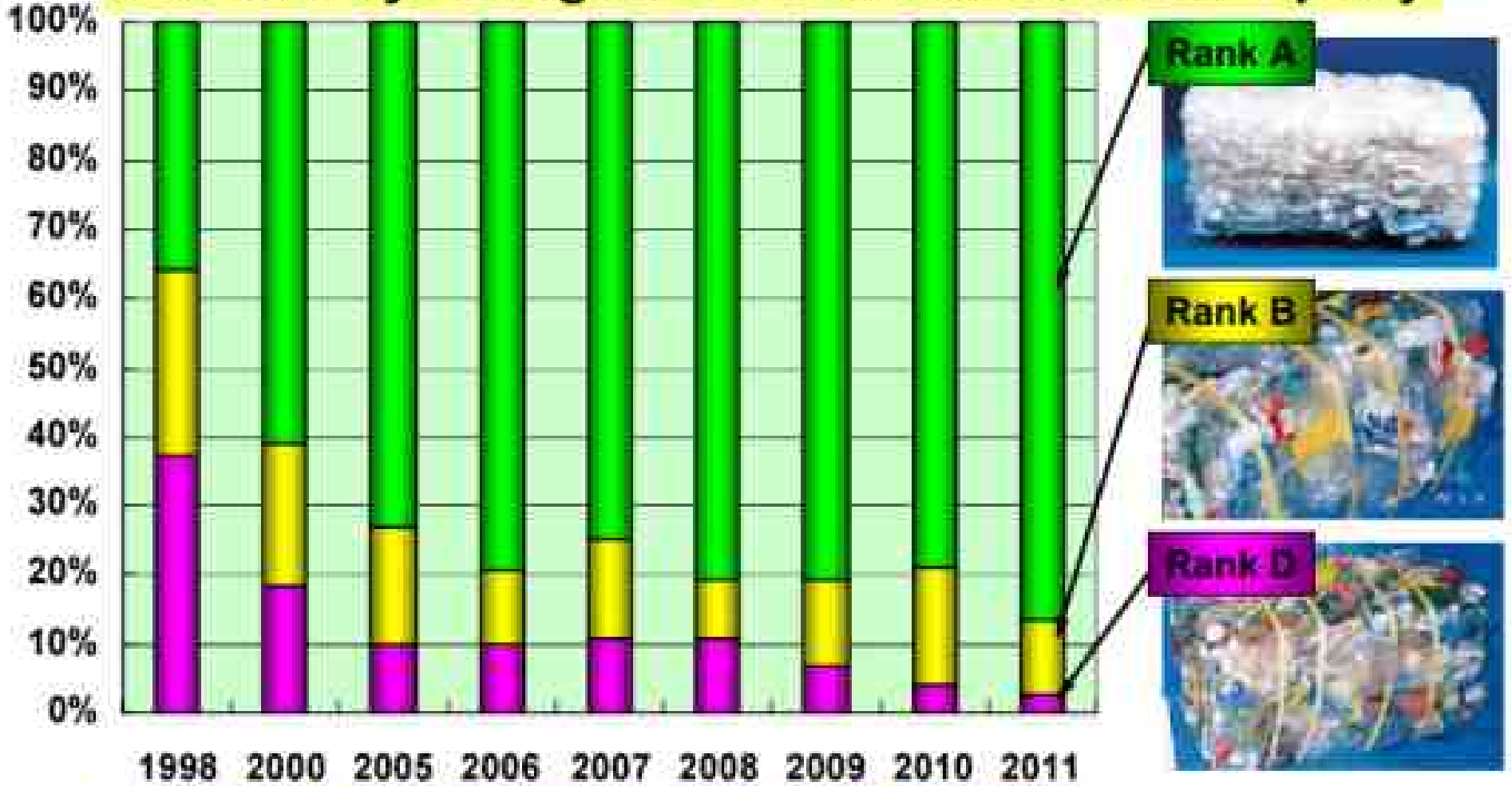
Bottles must be made of only Clear PET (no color). When use multi-layer / coating for barrier, must evaluate a recycling performance.

Labels must be easily removable by hand.

5. 3R (Reduce, Reuse, Recycle) in Japan

PET
CPBR.J

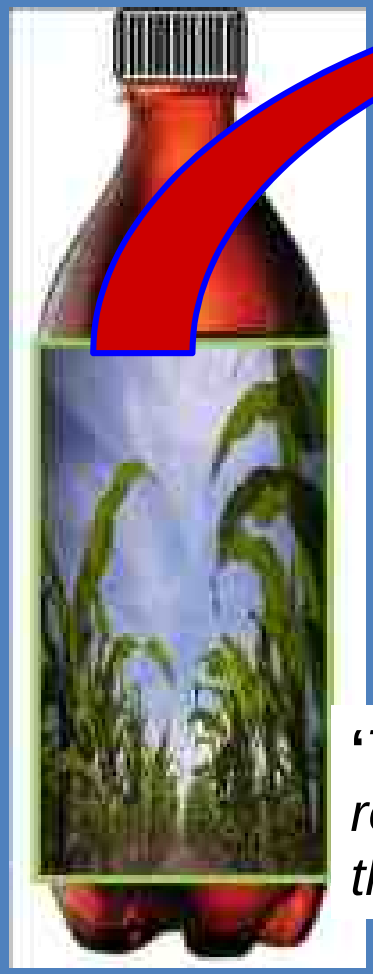
Bale Quality : Obligation of Consumers & Municipality



Data from the Japan Containers and Packaging Recycling Association http://www.jcpra.or.jp/

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

Potentially conflicting drivers

Can biodegradables reduce litter impacts?

‘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

Resource IN

Waste OUT

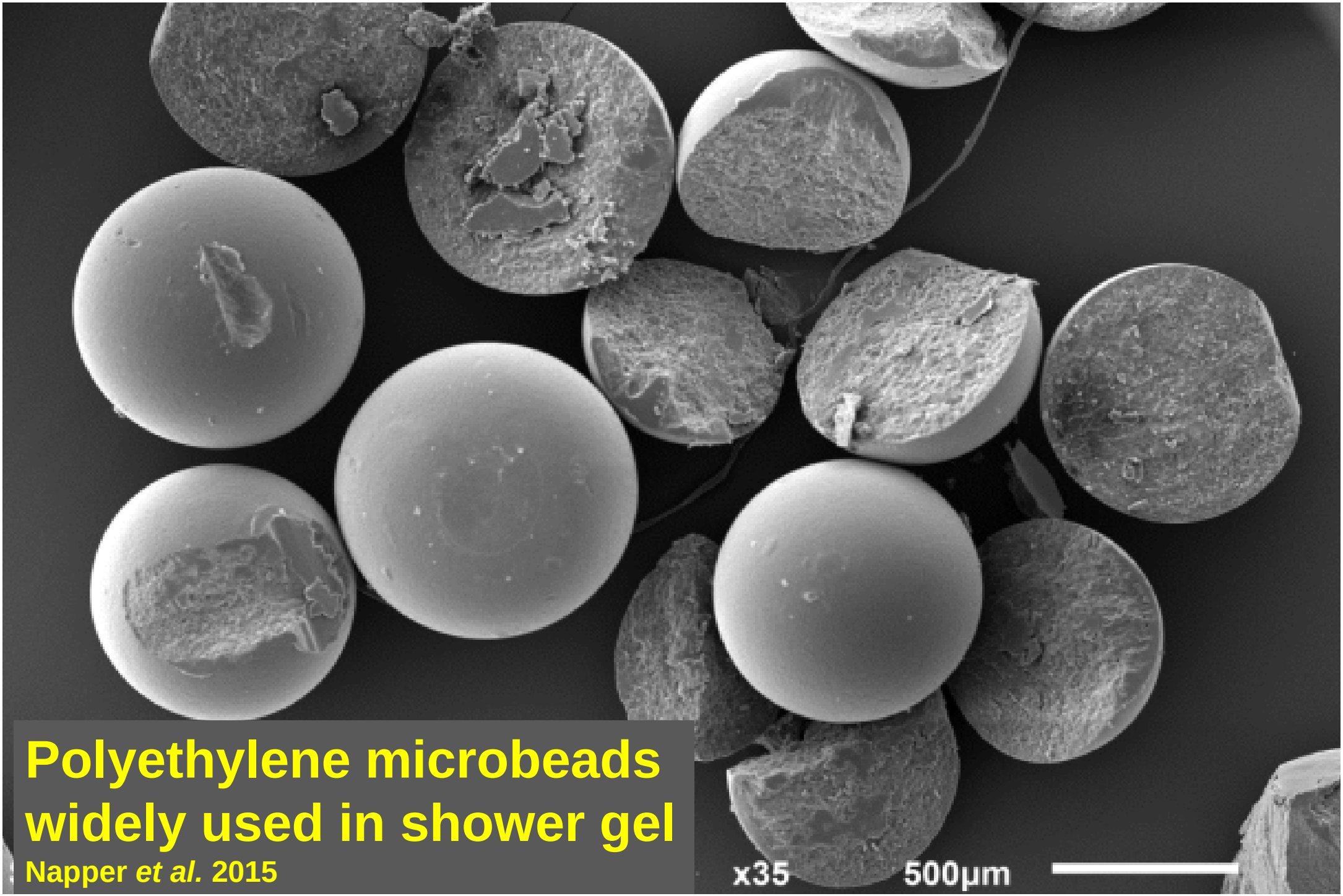
Towards a more circular economy

1) Design for product life, and end-of-life 2) label accordingly

Minimum material	√ yes		X no
Easy to recycle	√ yes		X no
Recycled content	√ yes		X no

Resource IN

Waste OUT



Polyethylene microbeads widely used in shower gel

Napper *et al.* 2015

Considerable regional variation - no single solution

Table 1. Waste estimates for 2010 for the top 20 countries ranked by mass of mismanaged plastic waste (in units of millions of metric tons per year). Econ classif., economic classification: HIC, high income; UMI, upper middle income; LMI, lower middle income; LI, low income (World Bank definitions based on 2010 Gross National Income). Mismanaged waste is the sum of inadequately managed waste plus 2% littering. Total mismanaged plastic waste is calculated for populations within 50 km of the coast in the 192 countries considered. pop., population; gen., generation; ppd, per son per day; MMT, million metric tons.

Rank	Country	Econ. classif.	Coastal pop. [millions]	Waste gen. rate [kg/ppd]	% plastic waste	% mismanaged waste	Mismanaged plastic waste [MMT/year]	% of total mismanaged plastic waste	Plastic marine debris [MMT/year]
1	China	UMI	262.9	1.10	11	76	8.82	27.7	1.32–3.53
2	Indonesia	LMI	187.2	0.52	11	83	3.22	10.1	0.48–1.29
3	Philippines	LMI	83.4	0.5	15	83	1.88	5.9	0.28–0.75
4	Vietnam	LMI	55.9	0.79	13	88	1.83	5.8	0.28–0.73
5	Sri Lanka	LMI	14.6	5.1	7	84	1.59	5.0	0.24–0.64
6	Thailand	UMI	26.0	1.2	12	75	1.03	3.2	0.15–0.41
7	Egypt	LMI	21.8	1.37	13	69	0.97	3.0	0.15–0.39
8	Malaysia	UMI	22.9	1.52	13	57	0.94	2.9	0.14–0.37
9	Nigeria	LMI	27.5	0.79	13	83	0.85	2.7	0.13–0.34
10	Bangladesh	LI	70.9	0.43	8	89	0.79	2.5	0.12–0.31
11	South Africa	UMI	12.9	2.0	12	56	0.63	2.0	0.09–0.25
12	India	LMI	187.5	0.34	3	87	0.60	1.9	0.09–0.24
13	Algeria	UMI	16.5	1.2	12	60	0.52	1.6	0.08–0.21
14	Turkey	UMI	34.0	1.77	12	18	0.49	1.5	0.07–0.19
15	Pakistan	LMI	14.6	0.79	13	88	0.48	1.5	0.07–0.19
16	Brazil	UMI	74.7	1.03	16	11	0.47	1.5	0.07–0.19
17	Burma	LI	19.0	0.44	17	89	0.46	1.4	0.07–0.18
18*	Morocco	LMI	17.3	1.46	5	68	0.31	1.0	0.05–0.12
19	North Korea	LI	17.3	0.6	9	90	0.30	1.0	0.05–0.12
20	United States	HIC	112.9	2.58	13	2	0.28	0.9	0.04–0.11

*If considered collectively, coastal European Union countries (23 total) would rank eighteenth on the list.

Jambeck *et al.* 2015

Marine litter:

1) is a symptom of inefficient outdated business model
2) is not directly coupled to societal benefits
3) damages resources (economy, wildlife, services)
4) Synergistic benefits (resource efficiency / waste reduction) achieved by product re-design
5) Solutions exist – but there is no single solution
6) is a highly visible, accessible, **emotive** problem – harness this interest and focus it on better product design and waste management

2016 New Year Symposium on Marine Litter

Ministry of the Environment, Government of Japan,
Tokyo University of Marine Science and Technology

Purpose of symposium:

The problem on marine litter has become serious at all over the world including Japan. Marine litter was acknowledged as a global challenge in the Leaders Declaration mutually agreed in G7 Elmau Summit, June, 2015.

'Invite researchers and share information'

There is considerable potential for G7 to work towards solutions by sharing good practice globally

Thank you for hosting this meeting

Richard Thompson - Thank you

SEA CHANGE WITH PLYMOUTH UNIVERSITY

5. 3R (Reduce, Reuse, Recycle) in Japan

Collection and Recycling Channel

PET
CPBR,J

Unit: 000 Tons