Sixth Regional 3R Forum in Asia and the Pacific

Aug. 18, 2015

Marine plastic pollution and its potential solution - Sustainable tourism

Hideshige Takada

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Topics

- Marine plastic problem and international responses
- Effects of marine plastics on marine organisms
- Solution: No single-use plastic
- Sustainable tourism

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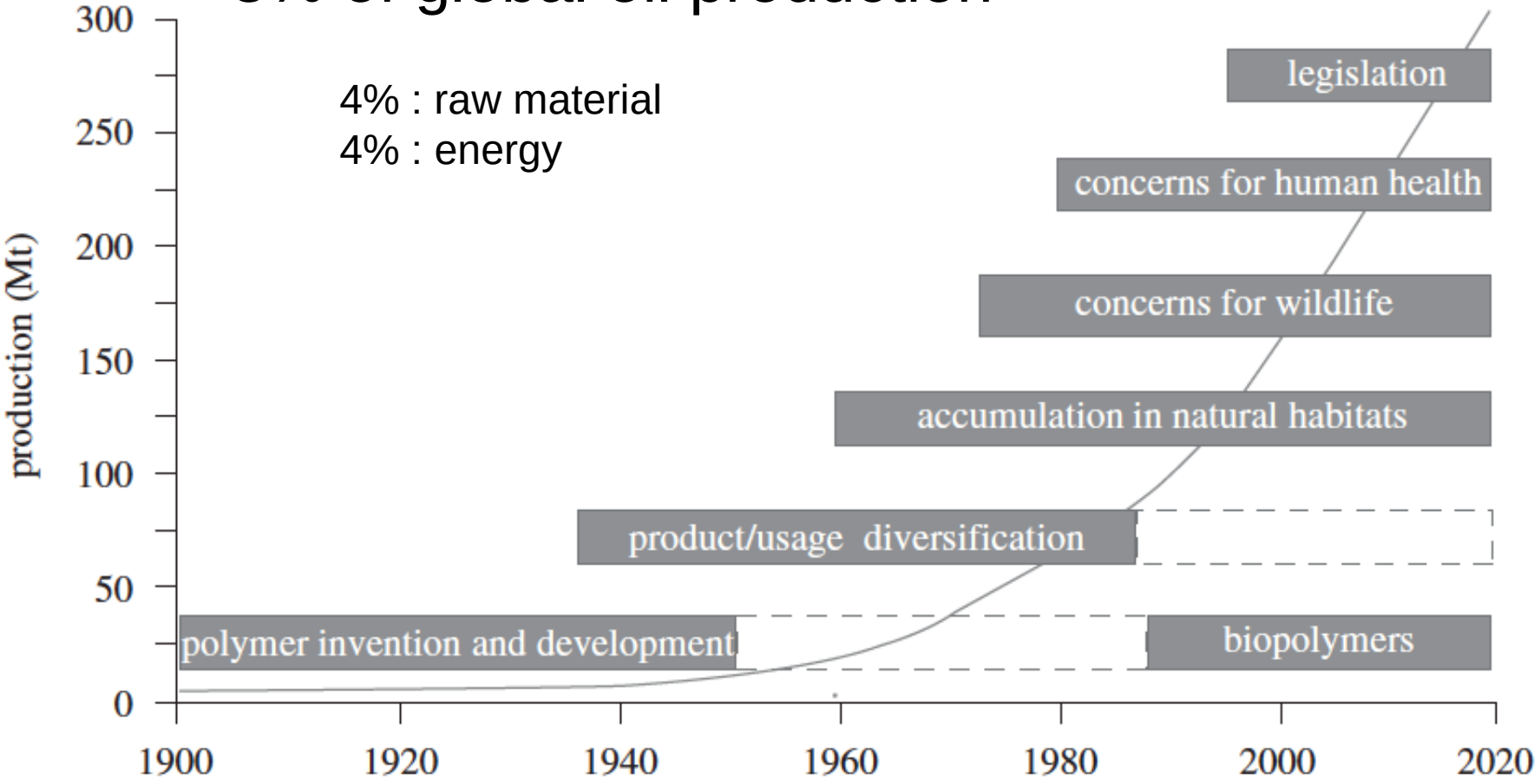
Continuous increase in plastic production

8% of global oil production

4% : raw material
4% : energy



1933:Production of Polyethylene started.

Thompson et al., 2009

First Alert of marine plastic pollution in 1972

Plastics on the Sargasso Sea Surface

Carpenter and Smith (1972) ***Science***, March 17 p.1240-1241.

Fig. 1. Typical plastic particles from tow 2. White pellets are on the left.

Plastic particle pollution of the surface of the Atlantic Ocean : Evidence from a seabird

Rothstein (1973),
The Condor, vol.75, p.344-345

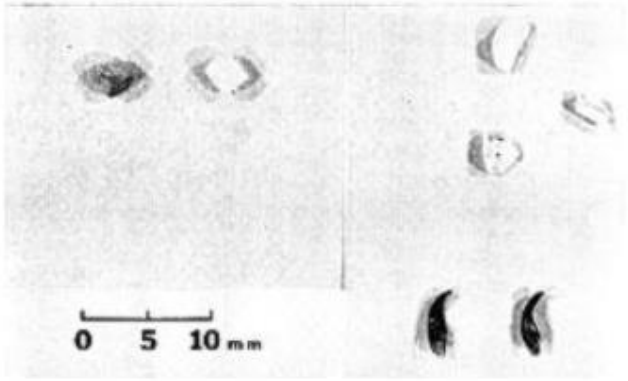
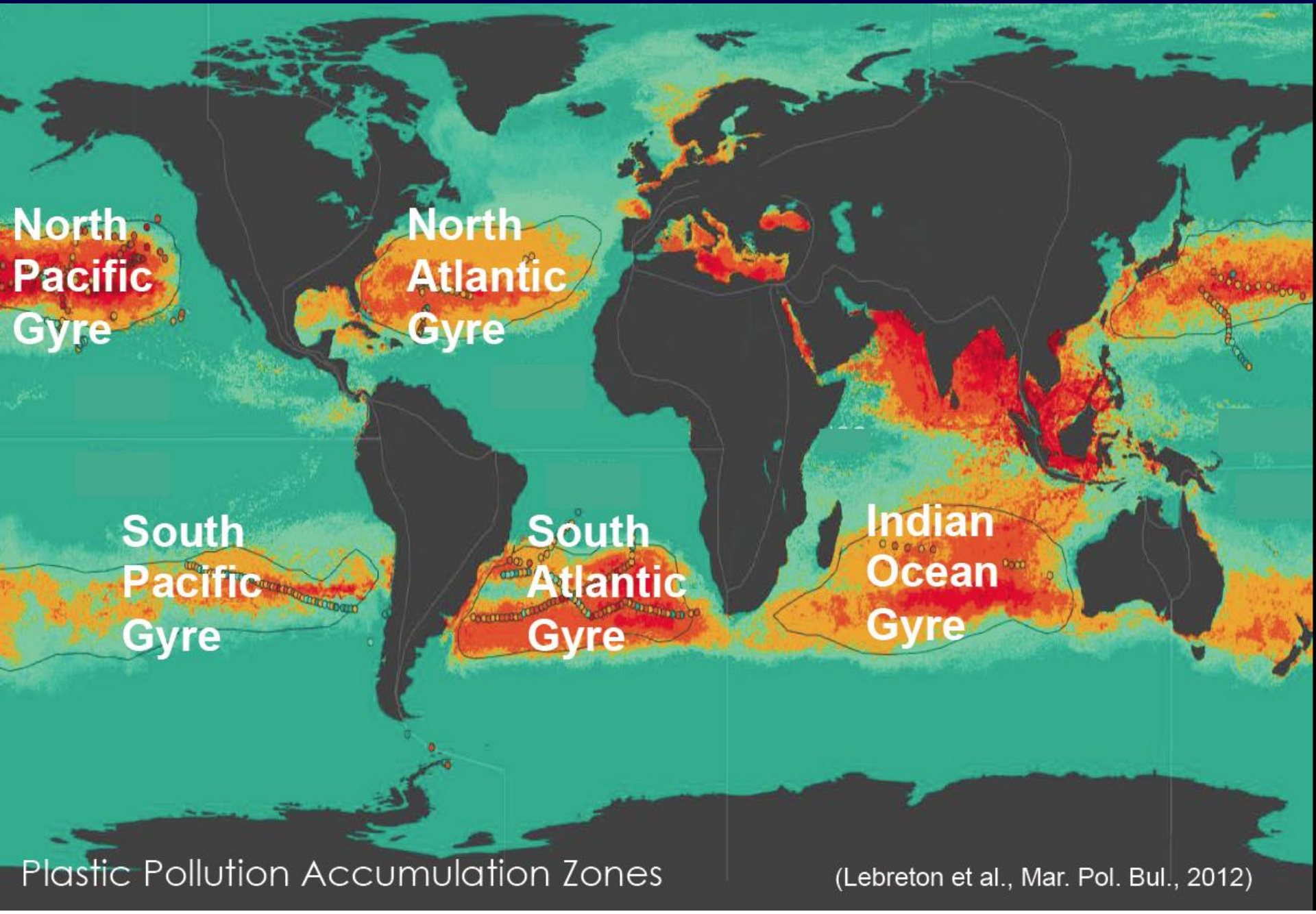


FIGURE 1. Objects found in the stomachs of two Leach's Petrels. The two pieces of plastic in the upper left corner were found in the gizzard of a petrel collected on Gull Island, Newfoundland. The three pieces of plastic as well as the two claw-like structures in the right half of the figure were all found in the gizzard of a petrel collected on Kent Island, New Brunswick. The claw-like structures have been tentatively identified as the pharyngeal teeth of a large polychaete.

Photo from Dr. Charles Moore

Captain Charles Moore discovered garbage patch in central pacific gyre in 1997

0.27 millions ton of plastics floating on world ocean



Plastic waste inputs to the sea will increase by a factor of **10 in coming 20 years**, if no action will be taken.

Plastic waste inputs from land into the ocean

Jenna R. Jambeck,[1]* Roland Geyer,[2] Chris Wilcox,[3] Theodore R. Siegler,[4] Miriam Perryman,[1] Anthony Andrady,[5] Ramani Narayan,[6] Kara Lavender Law[7]

Plastic debris in the marine environment is widely documented, but the quantity of plastic entering the ocean from waste generated on land is unknown. By linking worldwide data on solid waste, population density, and economic status, we estimated the mass of land-based plastic waste entering the ocean. We calculate that 275 million metric tons (MT) of plastic waste was generated in 192 coastal countries in 2010, with 4.8 to 12.7 million MT entering the ocean. Population size and the quality of waste management systems largely determine which countries contribute the greatest mass of uncaptured waste available to become plastic marine debris. Without waste management infrastructure improvements, the cumulative quantity of plastic waste available to enter the ocean from land is predicted to increase by an order of magnitude by 2025.

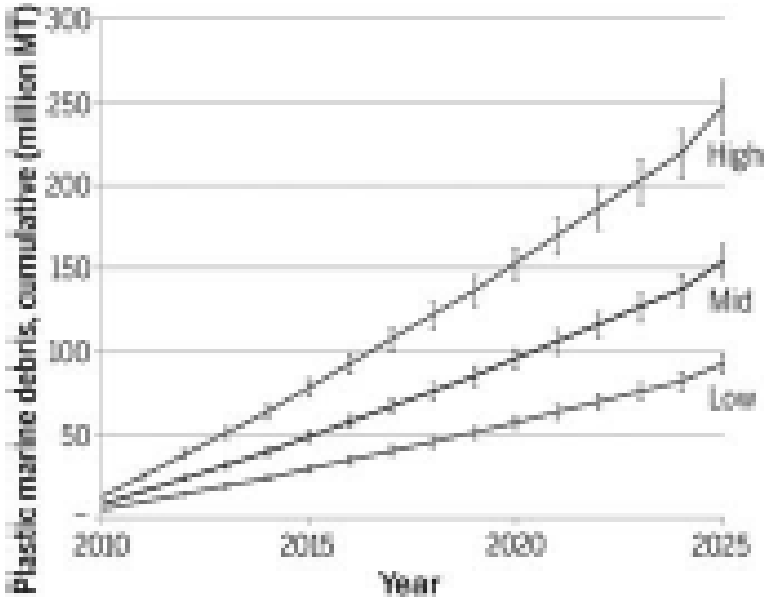


Fig. 2. Estimated mass of mismanaged plastic waste (millions of metric tons) input to the ocean by populations living within 50 km of a coast in 192 countries, plotted as a cumulative sum from 2010 to 2025. Estimates reflect assumed conversion rates of mismanaged plastic waste to marine debris (high, 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).

Jamebeck et al. (2015), Science

Increase in Academic and public attention on marine plastics in USA and Europe

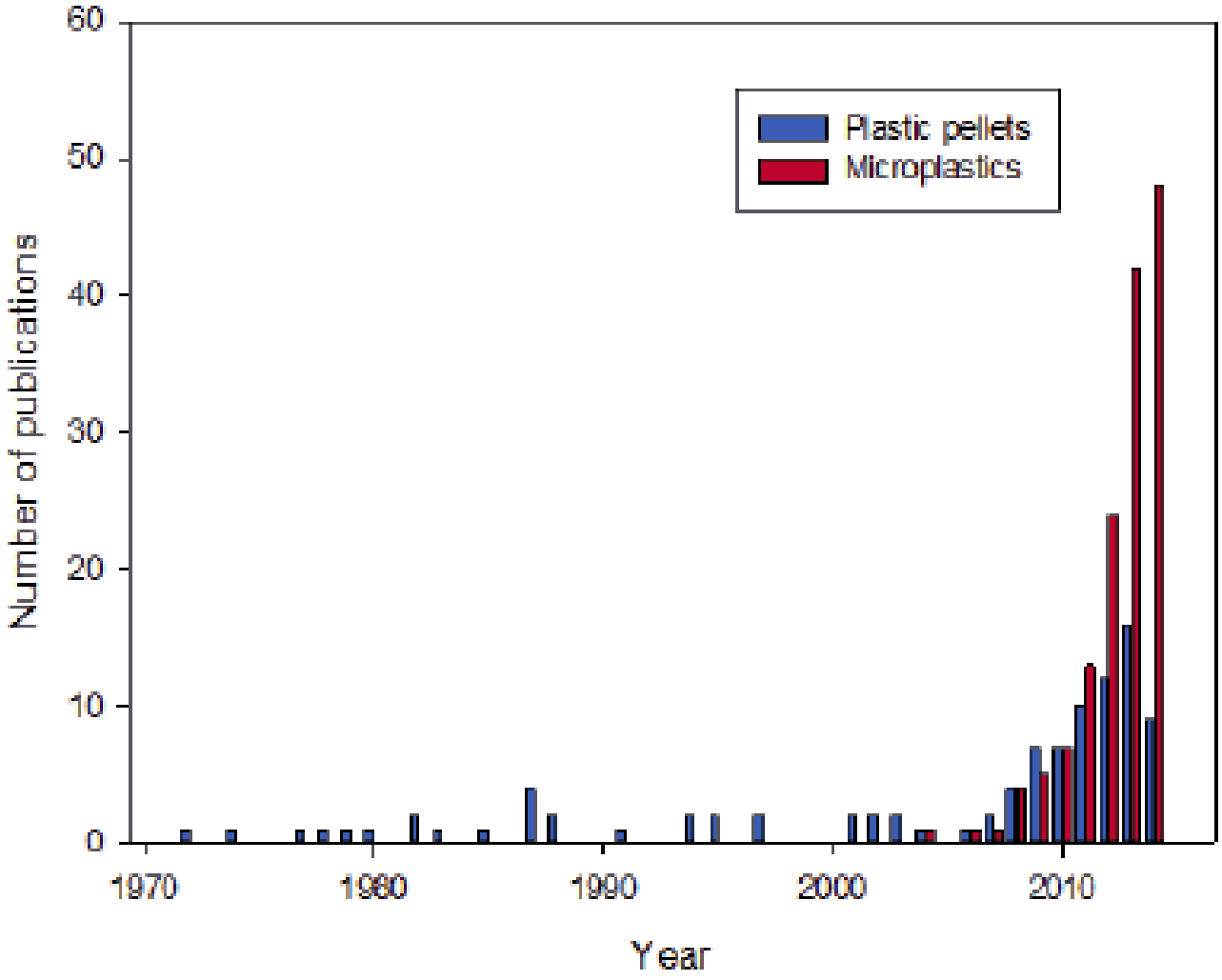
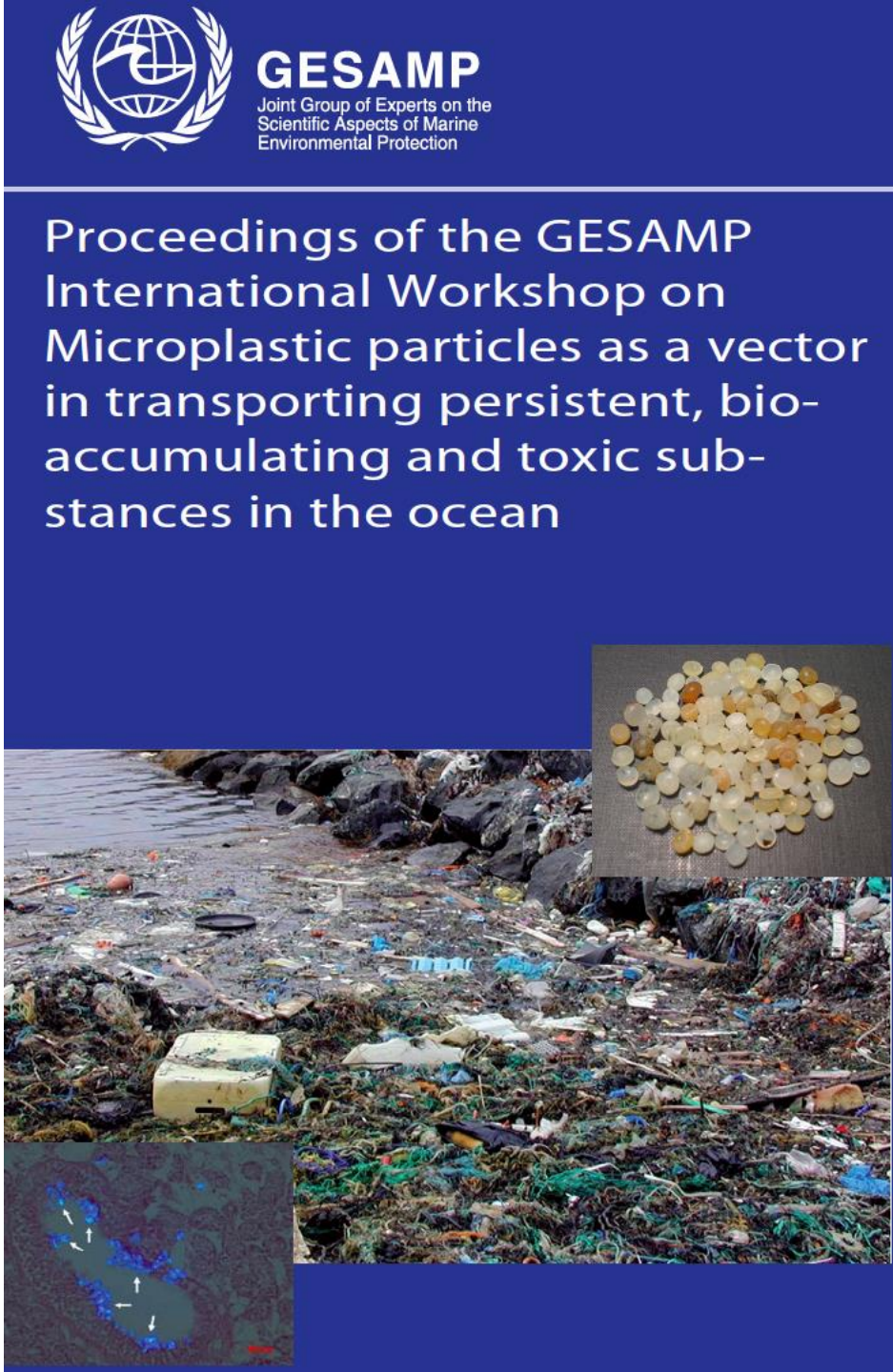


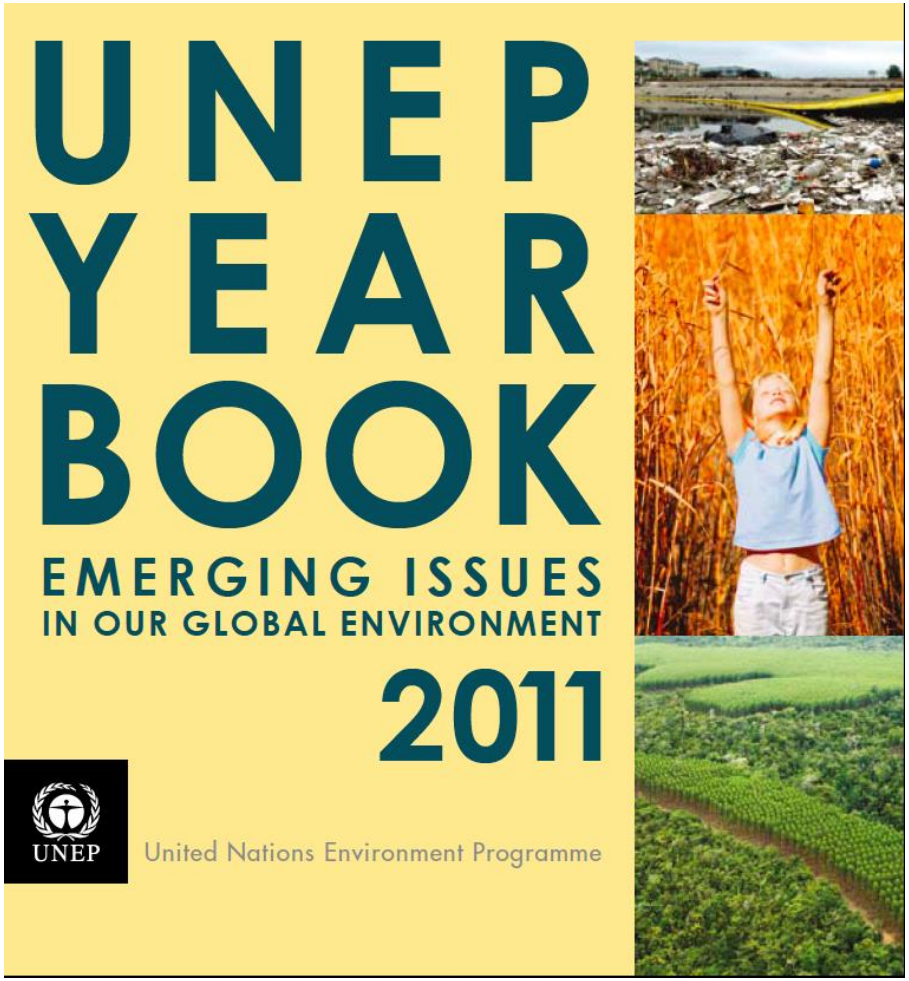
Figure 1.1 *Publications by year, 1970 – July 2014, using the search terms 'plastic pellets' and 'microplastics' – compiled by Sarah Gall, Univ. Plymouth, UK.*

GESAMP

(Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection of IMO/FAO/UNESCO/WHO/IAEA/UN/UNEP)

Workshop Report
2010





Plastic Debris in the Ocean

Every year large amounts of plastic debris enter the ocean, where it slowly fragments and accumulates in convergence zones. Scientists are concerned about the possible impacts of small plastic fragments—microplastics—in the environment. The role of plastics as a vector for transporting chemicals and species in the ocean is as yet poorly understood, but it is a potential threat to ecosystems and human health. Improved waste management is the key to preventing plastic and other types of litter from entering the ocean.

The ocean has become a global repository for much of the waste we generate. Marine debris includes timber, glass, metal and plastic from many different sources. Recently, the accumulation and possible impacts of microplastic particles in the ocean have been recognized as an emerging environmental issue. Some scientists are increasingly concerned about the potential impact of releases of persistent bio-accumulating and toxic compounds (PBTs) from plastic debris. At the same time, the fishing and tourism industries in many parts of the world are affected economically by plastic entering nets, fouling propellers and other equipment, and washing up on beaches. Despite international efforts to stem the flow of plastic debris, it continues to accumulate and impact the marine environment. To reduce the quantity of plastic entering the ocean, existing management instruments need to be made more effective and all aspects of waste treatment and disposal need to be improved.

Several common types of plastic are buoyant and have been transported by ocean currents to the remotest regions of the planet, including the Arctic and Antarctic (Barnes et al. 2010). Media attention has focused on reports of the relatively high incidence of plastic debris in areas of the ocean referred to as 'convergence zones' or 'ocean gyres'. This has given rise to the widespread use of terms like 'plastic soup', 'garbage patch' and 'ocean landfill'. Such terms are rather misleading in that much of the plastic debris in the ocean consists of fragments that are very small in size while the areas where they are floating are not, for example, distinguishable on satellite images. Nevertheless, publicity resulting from media reports and from the activities of several NGOs has helped to raise public and political awareness of the global scale of the plastic debris problem, together with the larger issue of marine litter.

Microplastics are generally considered to be plastic particles smaller than 5 millimetres in diameter (Arthur et al. 2009).

Persistent, bio-accumulating and toxic substances (PBTs) have a range of chronic health effects, including endocrine disruption, mutagenicity and carcinogenicity. A subset is regulated under the Stockholm Convention on Persistent Organic Pollutants (POPs).

Assessing the extent of the problem

It is difficult to quantify the amounts and sources of plastic and other types of debris entering the ocean. Land-based sources include poorly managed landfills, riverine transport, untreated sewage and storm water discharges, industrial and manufacturing facilities with inadequate controls, wind-blown debris, recreational use of coastal areas, and tourist activities (Barnes et al. 2009). These sources are thought to dominate the overall supply of marine debris, but there are important regional variations. For example, shipping and fisheries are significant contributors in the East Asian Seas region and the southern North Sea (UNEP/COBSEA 2009, Galgani et al. 2010). In general, more litter is found closer to population centres, including a greater proportion of consumer plastic items such as bottles, shopping bags and personal hygiene products (Ocean Conservancy 2010).

The greatest technological development of modern plastics occurred during the first half of the 20th century. Their production and use have continued to expand rapidly up to the present day (**Figure 1**). In many sectors, they have become a popular material for packaging (**Box 1**). A major benefit of their use in the food industry is that it can extend shelf life, thus decreasing the risk of infection and reducing food waste.

Ship- and platform-based sources of plastic litter in the ocean include fishing and recreational vessels, cruise liners, merchant shipping, oil and gas platforms, and aquaculture facilities (**Figure 2**).

Authors: Peter Kershaw (chair), Saido Katsuhiko, Sangjin Lee, Jon Samseth and Doug Woodring
Science writer: John Smith

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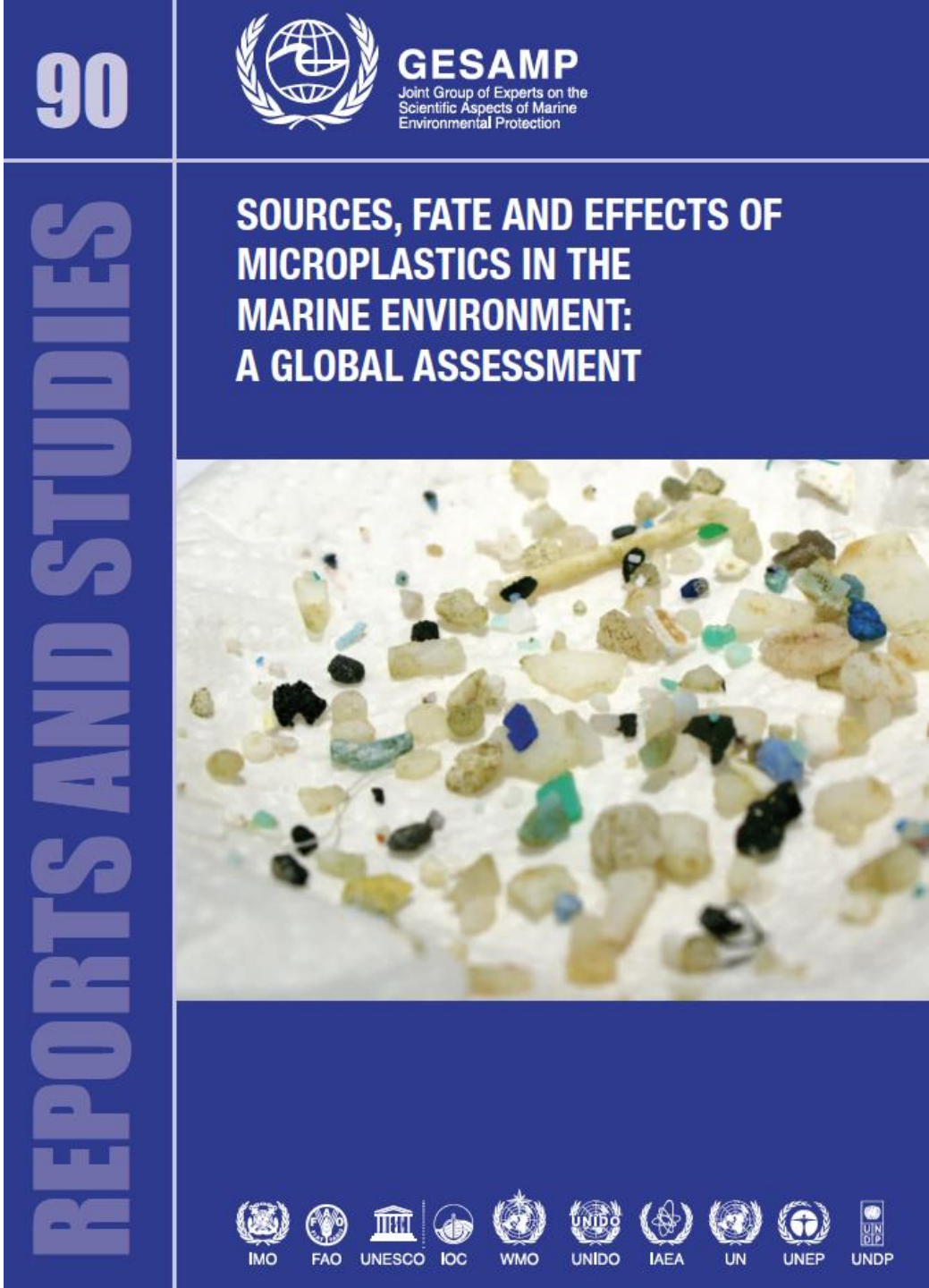
WG40 Microplastic

2012-2014



GESAMP Working group (2nd phase) on microplastics

April 15th – 17th, 2015

June : G7 Leaders' Declaration

Concern :

Contamination of **seafood** with microplastics and associated chemicals

Topics

- Marine plastic problem and international responses
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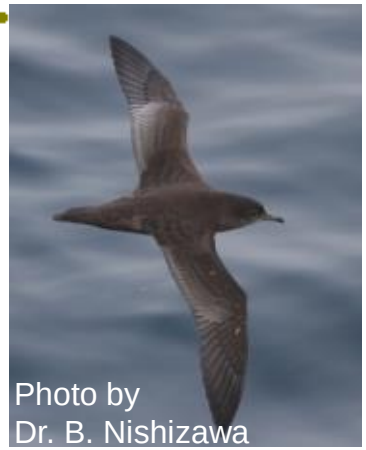
- Solution: No single-use plastic
- Sustainable tourism

Marine organisms ingest plastics

Albatross

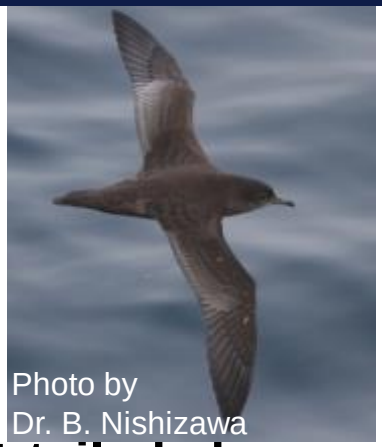
Short-tailed shearwater from Northern pacific

T/V *Wakatake Maru* (Hokkaido Pref.)
By-catch in driftnet
June-July 2003, 2005

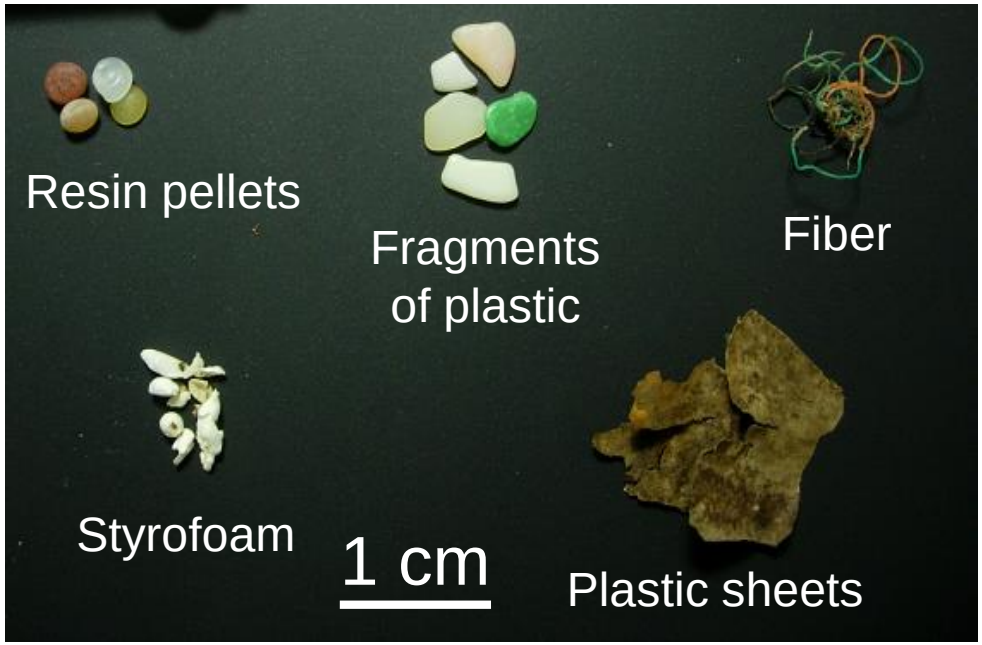


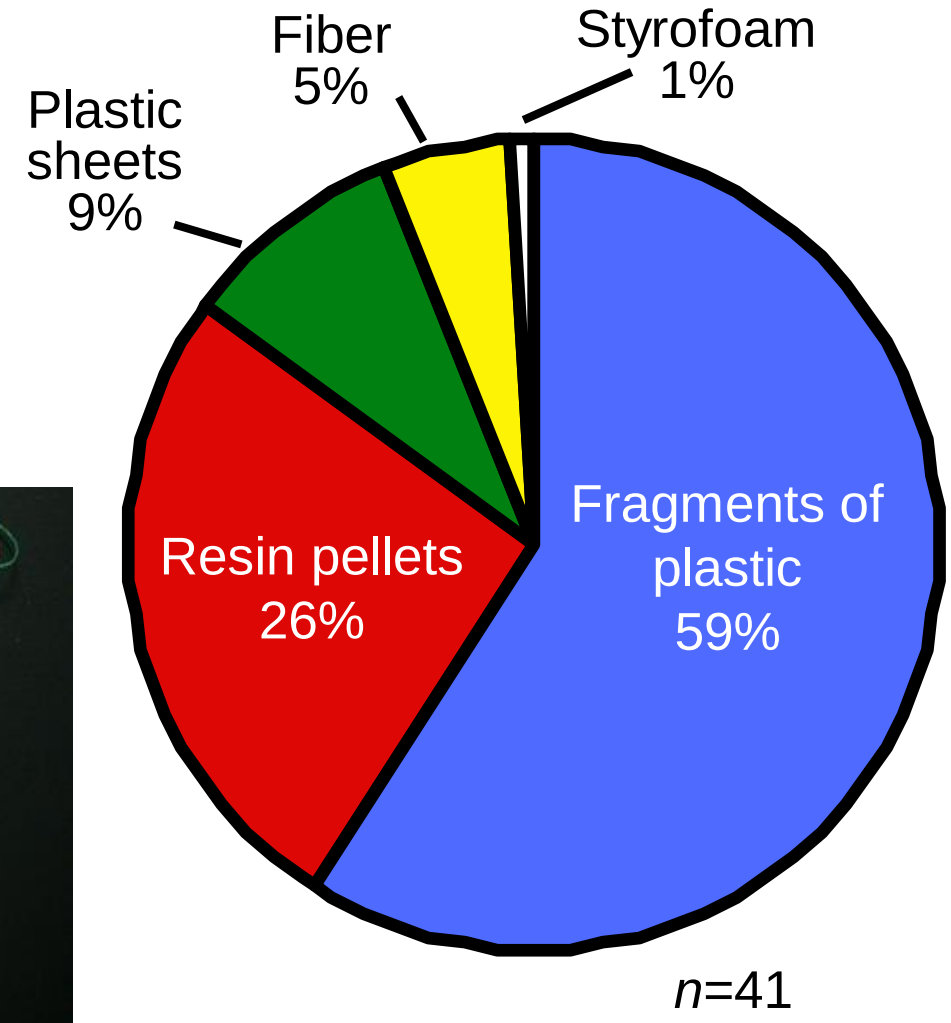
Sampling area
40˚00'N–47˚30'N, 180˚00'
55˚30'N–58˚30'N, 178˚00' E–178˚00' W

Plastics found in digestive tracts of the seabirds



Short-tailed shearwater
Puffinus tenuirostris





Type and composition of plastics found in the stomachs of short-tailed shearwater.

Yamashita et al. 2011

Plastics detected in digestive tract of short-tailed shearwater

0.1 g – 0.6 g per an individual

Marine organisms ingest plastics

More than 200 species of animals are known to have ingested plastic debris, including birds, fish, turtles and marine mammals.

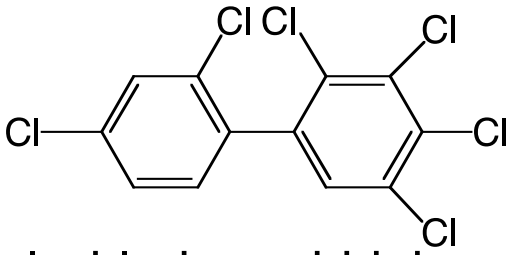
Physical impacts of the ingested plastics have been reported for many species of organisms (Wright et al., 2013).

Plastics in Seabird

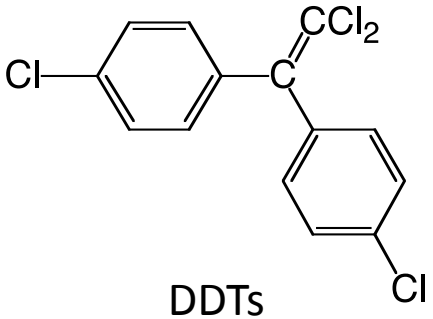
Plastics in Sea Turtle

Plastics carry hazardous chemicals in marine environment

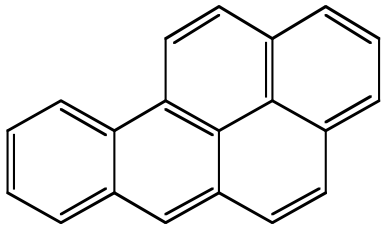
Sorption from ambient seawater



Polychlorinated biphenyl (PCBs)

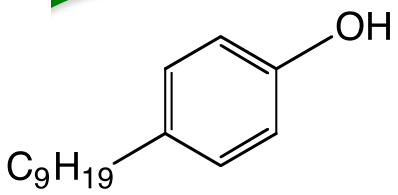


DDTs

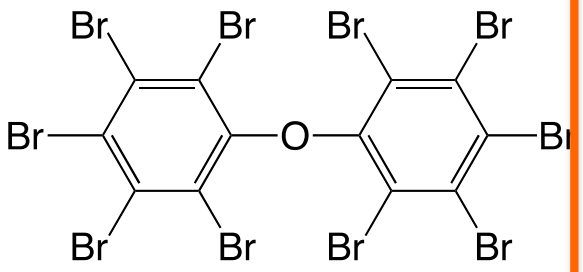


Polycyclic aromatic hydrocarbons (PAHs)

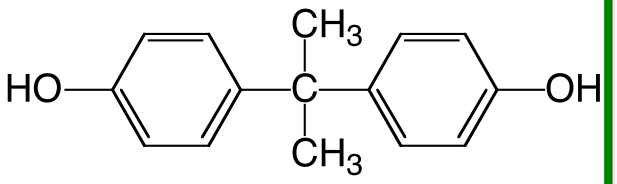
Additive-derived chemicals



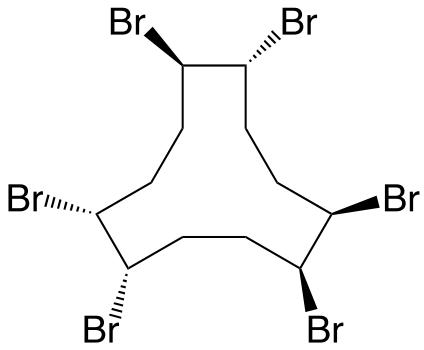
Nonylphenol



Polybrominated diphenyl ethers (PBDEs)



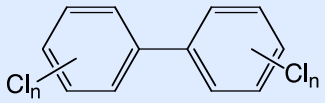
Bisphenol A



Hexabromocyclododecanes (HBCDs)

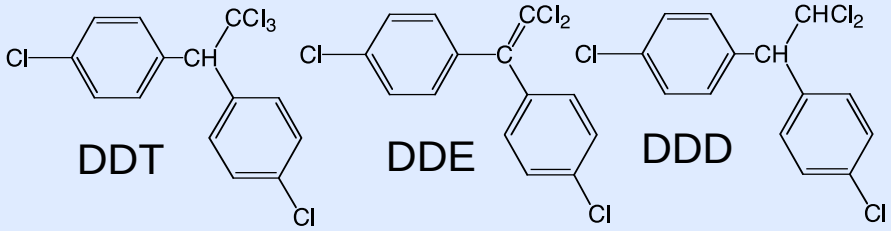
Persistent organic pollutants (POPs)

PCBs



- Industrial products for a variety of uses including dielectric fluid, heat medium, and lubricants.
- Endocrine disrupting chemicals

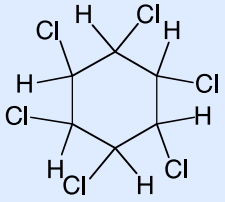
DDTs



- DDT and its metabolites such as DDE and DDD.
- DDT was used as insecticides
- Endocrine disrupting chemicals

- ✓Man-made chemicals
- ✓Persistent (stable, resistant to degradation)
- ✓Toxic to human and marine organisms
- ✓Hydrophobic (lipophilic)
- ✓Bioaccumulative

HCH

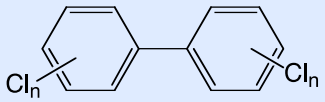


- Insecticide

Regulated by Stockholm convention

Plastics accumulate POPs from seawater

PCBs



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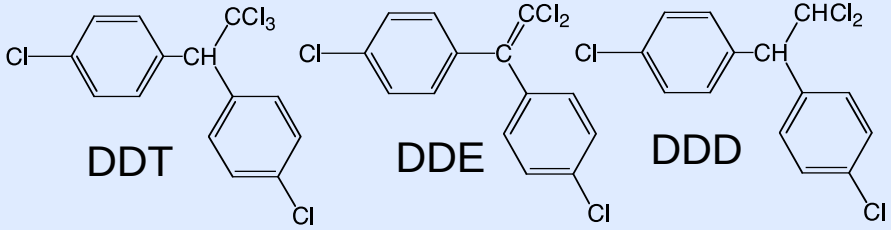

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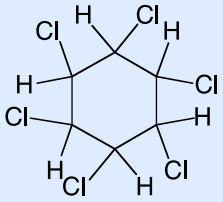
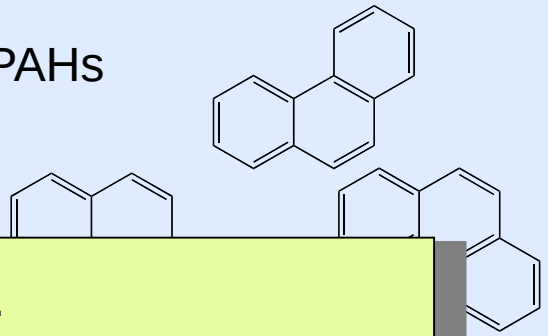
adsorption from ambient seawater

Plastics

HCH



PAHs



Concentration factor is estimated to be ~ 10^5 to ~10^6.

International Pellet Watch

Global Monitoring of Persistent Organic Pollutants (POPs) Using Beached Plastic Resin Pellets

More than 50 pieces (~ 100 pieces)
per one location

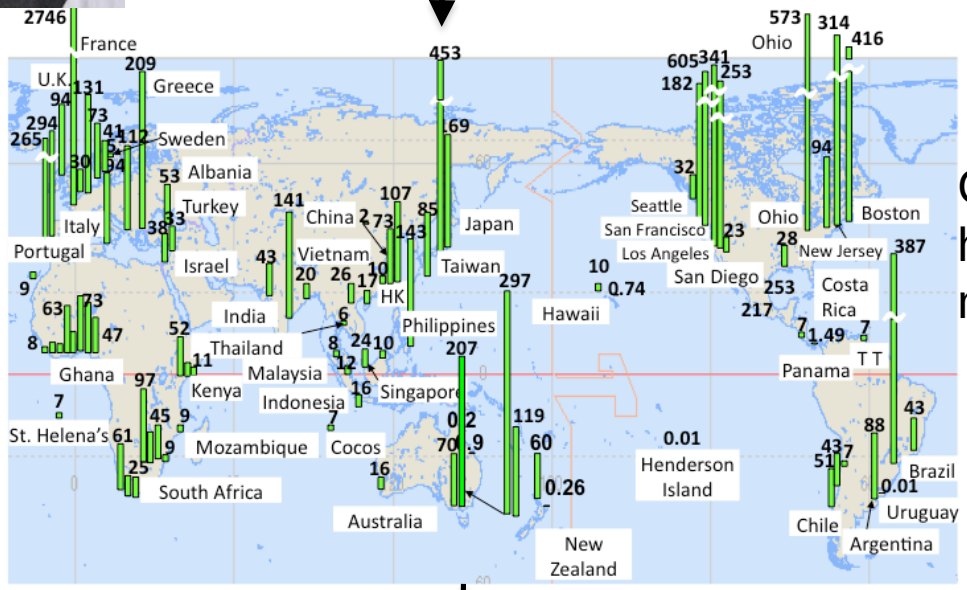
**Laboratory of Organic Geochemistry, Dr. Hideshige Takada,
Tokyo University of Agriculture and Technology,
Fuchu, Tokyo 183-8509, Japan**

Plastic resin pellet from various areas in the world

Analysis for persistent organic pollutants (POPs)

Chemical Analysis

Status of Global pollution

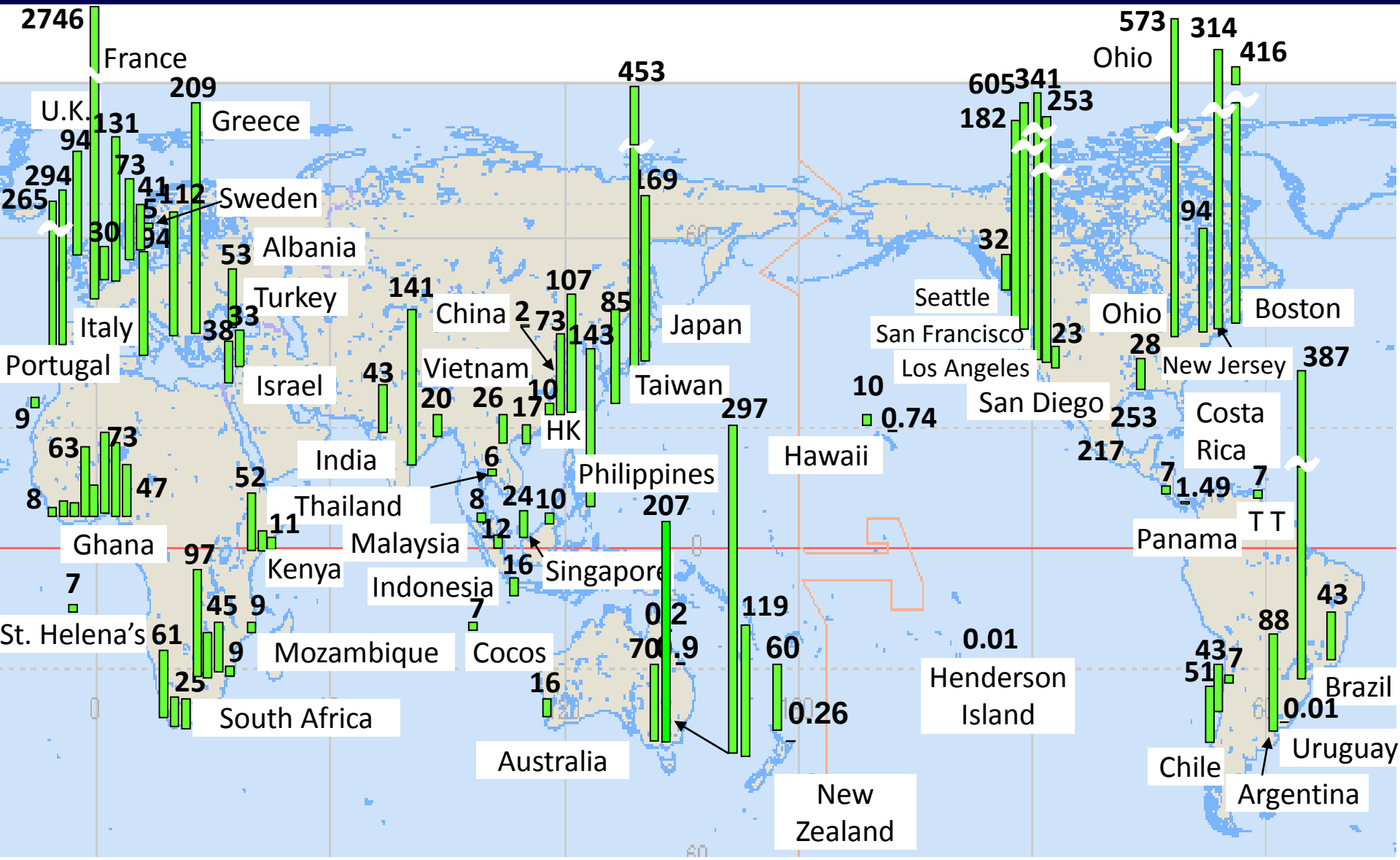


Chemical hazardousness of marine plastics

- **Feed the data** back to the collaborators via e-mail
- **Releasing** the results on **web**

http://**www.pelletwatch.org/**

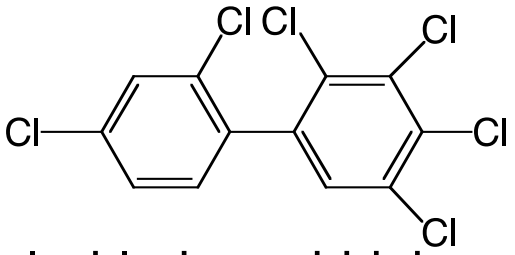
International Pellet Watch demonstrates that plastics carry hazardous chemicals in marine environments



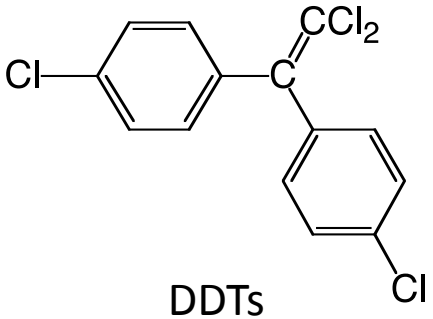
Concentration of PCBs* in beached plastic resin pellet (ng/g-pellet)

Plastics carry hazardous chemicals in marine environment

Sorption from ambient seawater



Polychlorinated biphenyl (PCBs)



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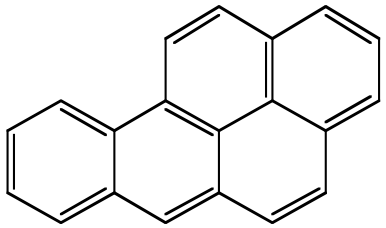
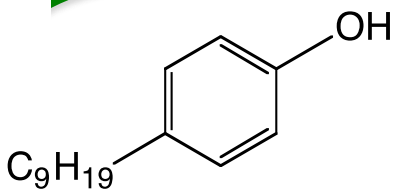
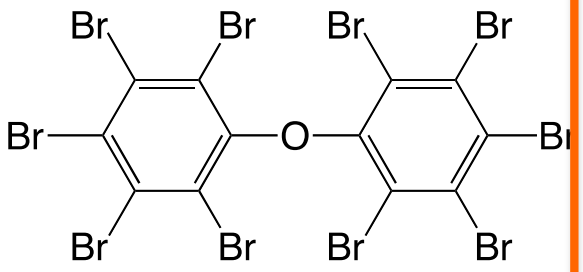


Polycyclic aromatic hydrocarbons (PAHs)

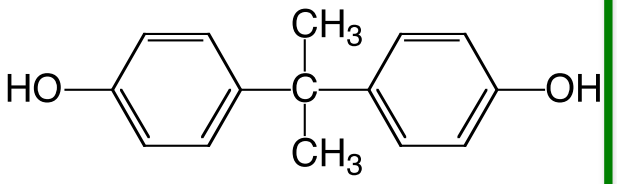
Additive-derived chemicals



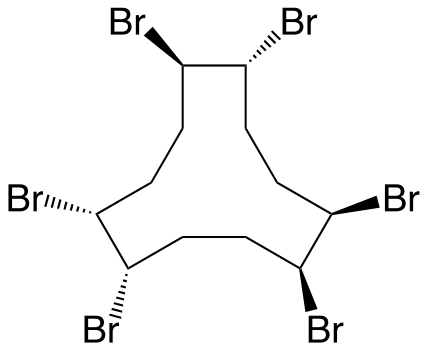
Nonylphenol



Polybrominated diphenyl ethers (PBDEs)



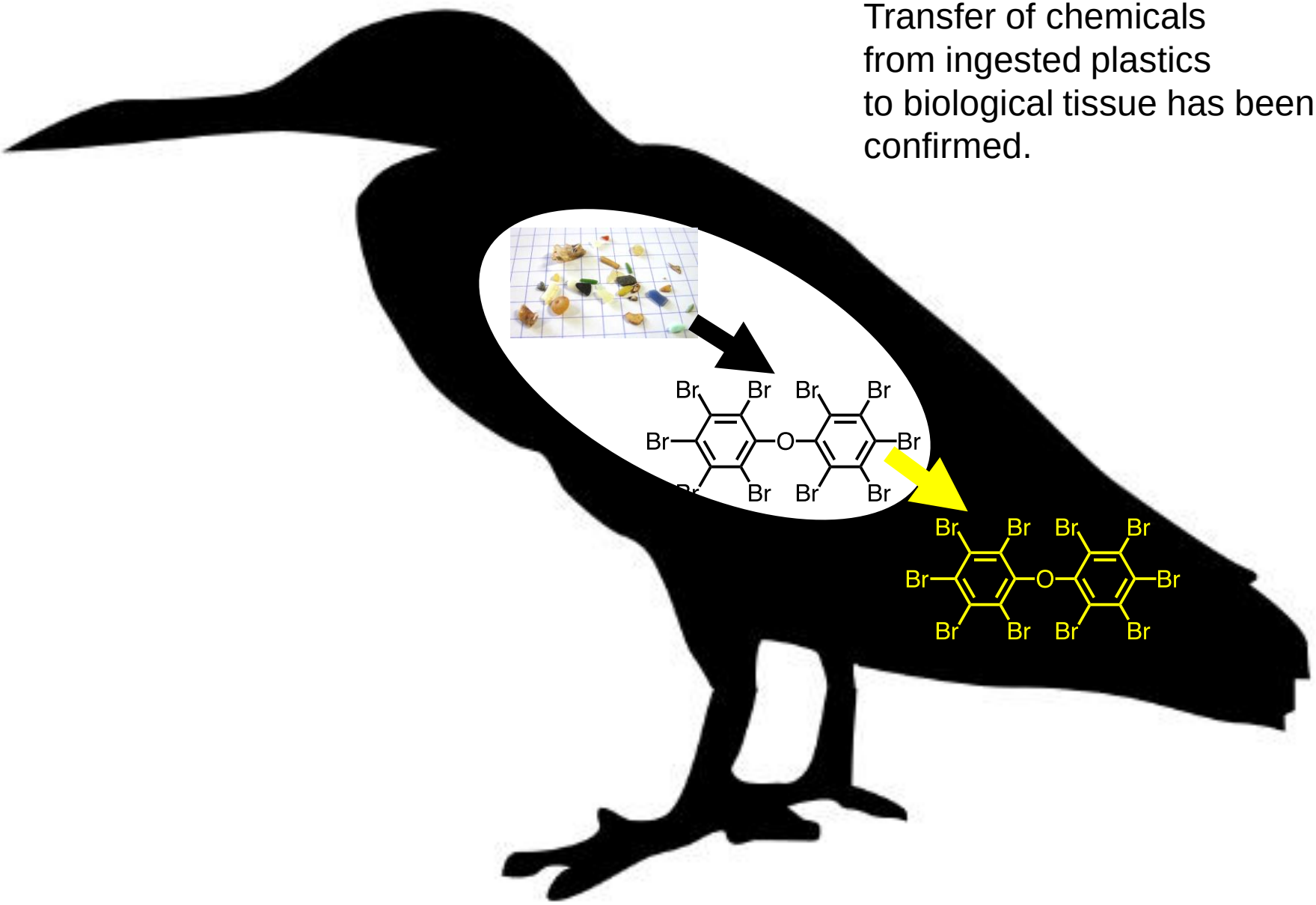
Bisphenol A



Hexabromocyclododecanes (HBCDs)

Transfer of chemicals from ingested plastics to biological tissue

Transfer of chemicals from ingested plastics to biological tissue has been confirmed.

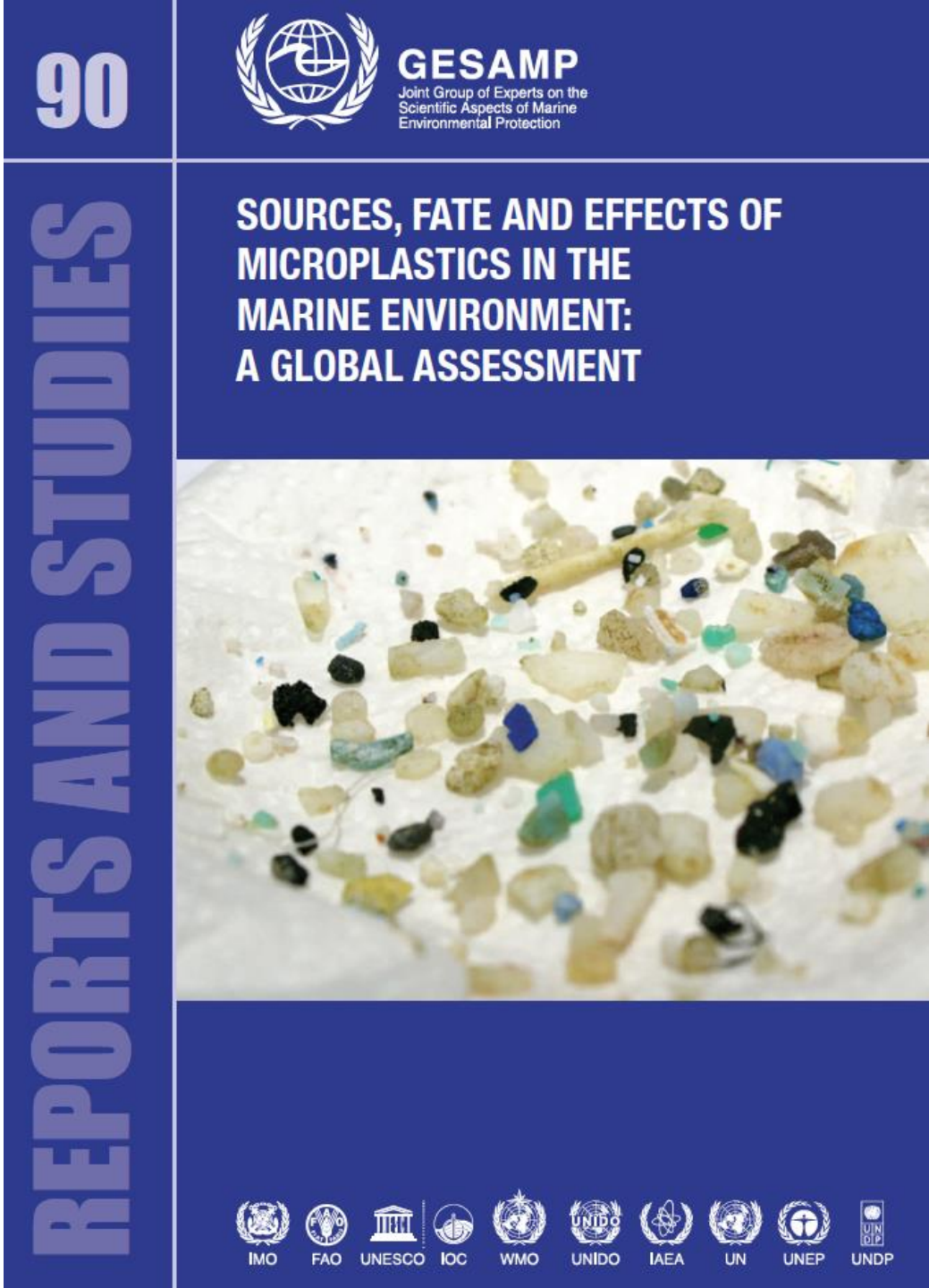


GESAMP

(Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection of IMO/FAO/UNESCO/WHO/IAEA/UN/UNEP)

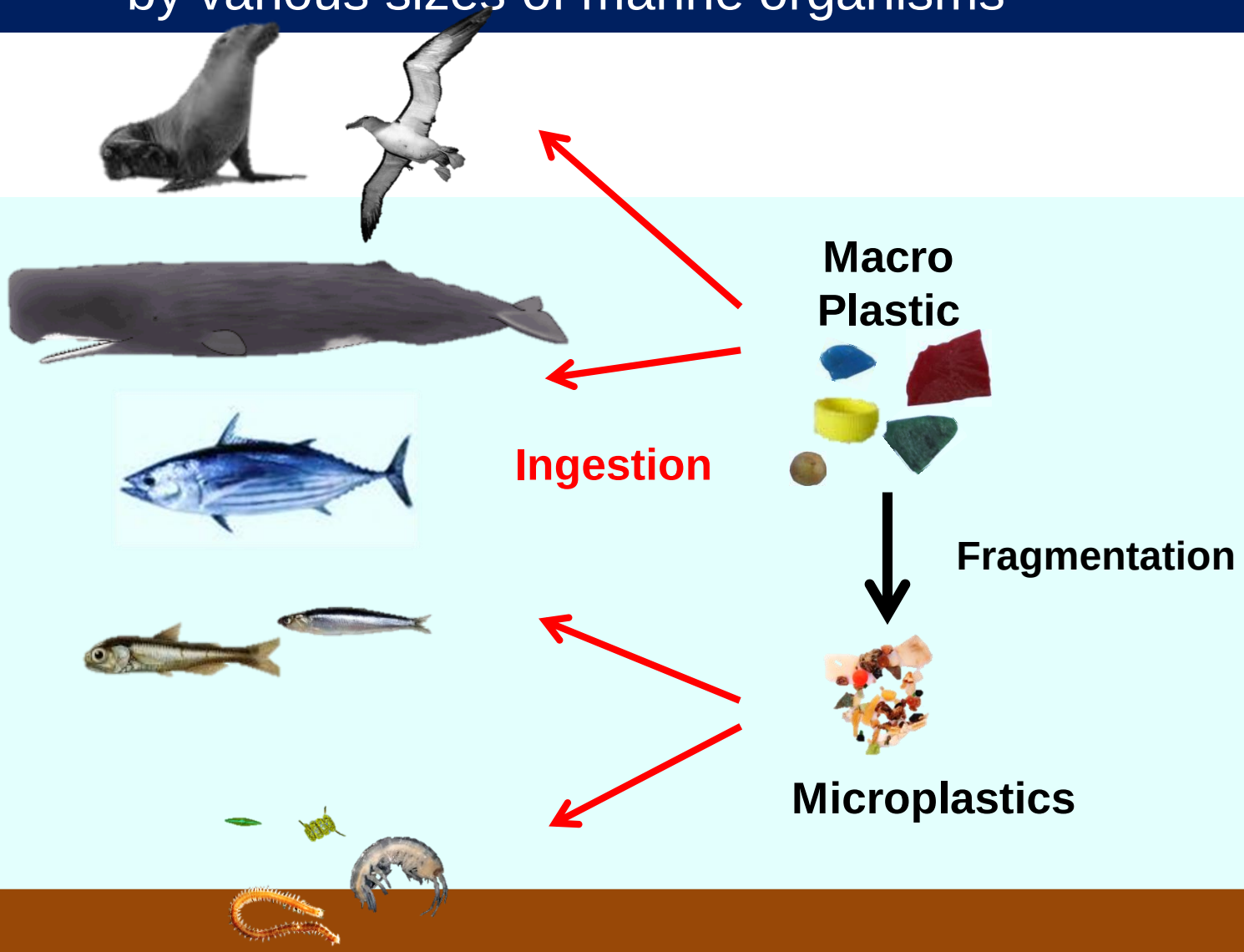
WG40 Microplastic

2012-2014



Fragmentation of plastics into μm size, nm size

Plastics are fragmented into smaller particles (i.e. microplastics) and various sizes of marine plastics are ingested by various sizes of marine organisms



Microplastics in seafood (e.g., mussel and oyster)

Microplastics in bivalves cultured for human consumption

Lisbeth Van Cauwenberghe*, Colin R. Janssen

Ghent University, Laboratory of Environmental Toxicology and Aquatic Ecology, Jozef Plateaustraat 22, 9000 Ghent, Belgium

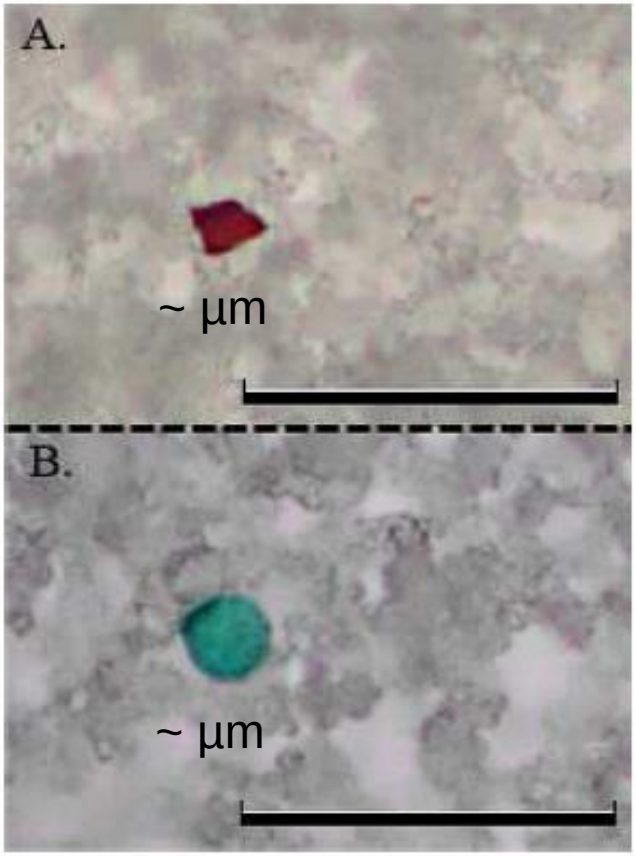
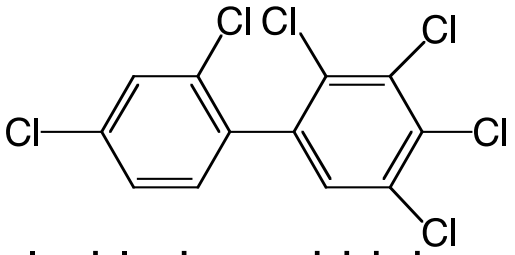


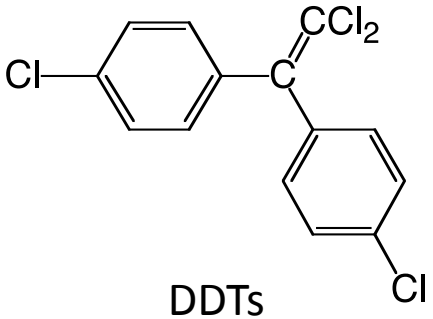
Fig. 1. Microplastics detected in the acid digested *Mytilus edulis* and *Crassostrea gigas*. A. Red particle recovered from *Mytilus edulis*; B. Green sphere detected in the soft tissue of *Crassostrea gigas*. (Scale bar: 50 µm). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Plastics carry hazardous chemicals in marine environment

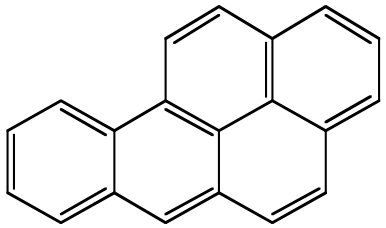
Sorption from ambient seawater



Polychlorinated biphenyl (PCBs)

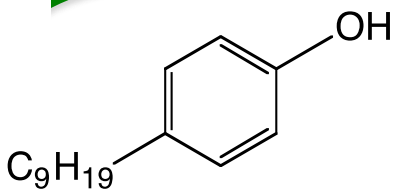


DDTs

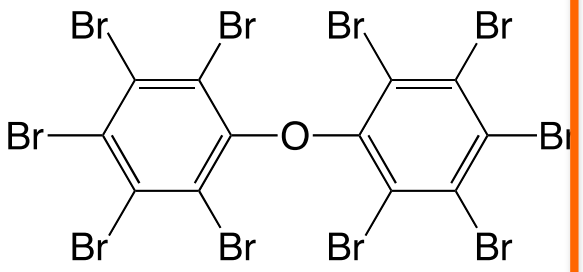


Polycyclic aromatic hydrocarbons (PAHs)

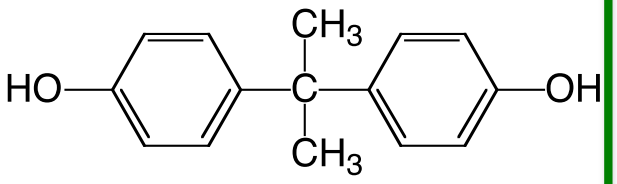
Additive-derived chemicals



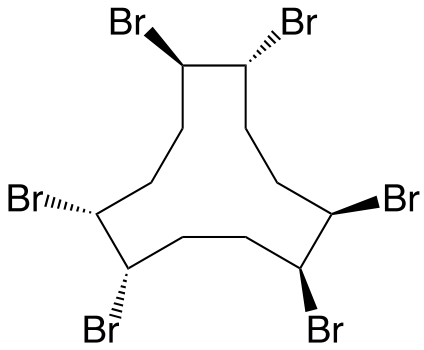
Nonylphenol



Polybrominated diphenyl ethers (PBDEs)

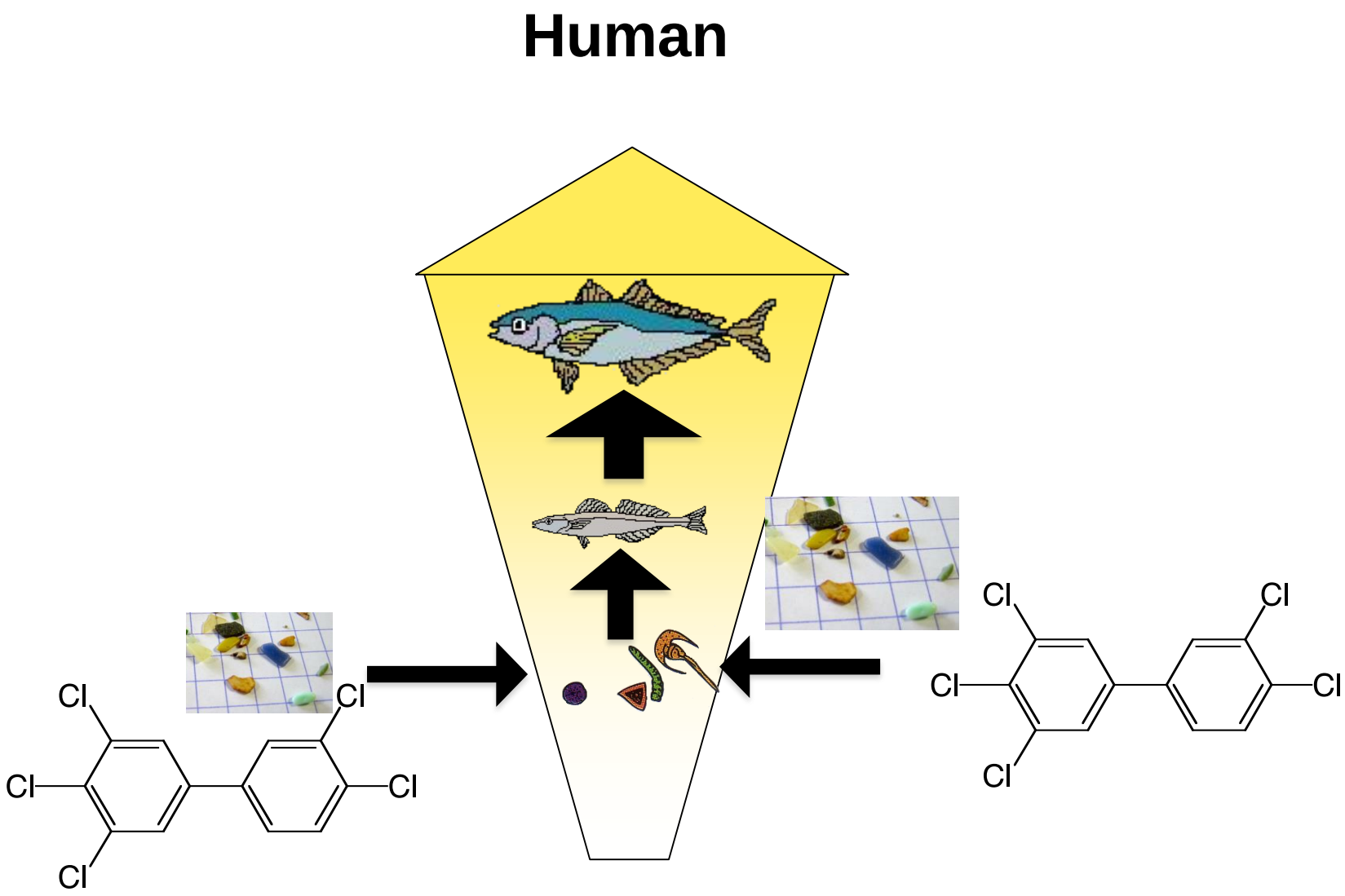


Bisphenol A

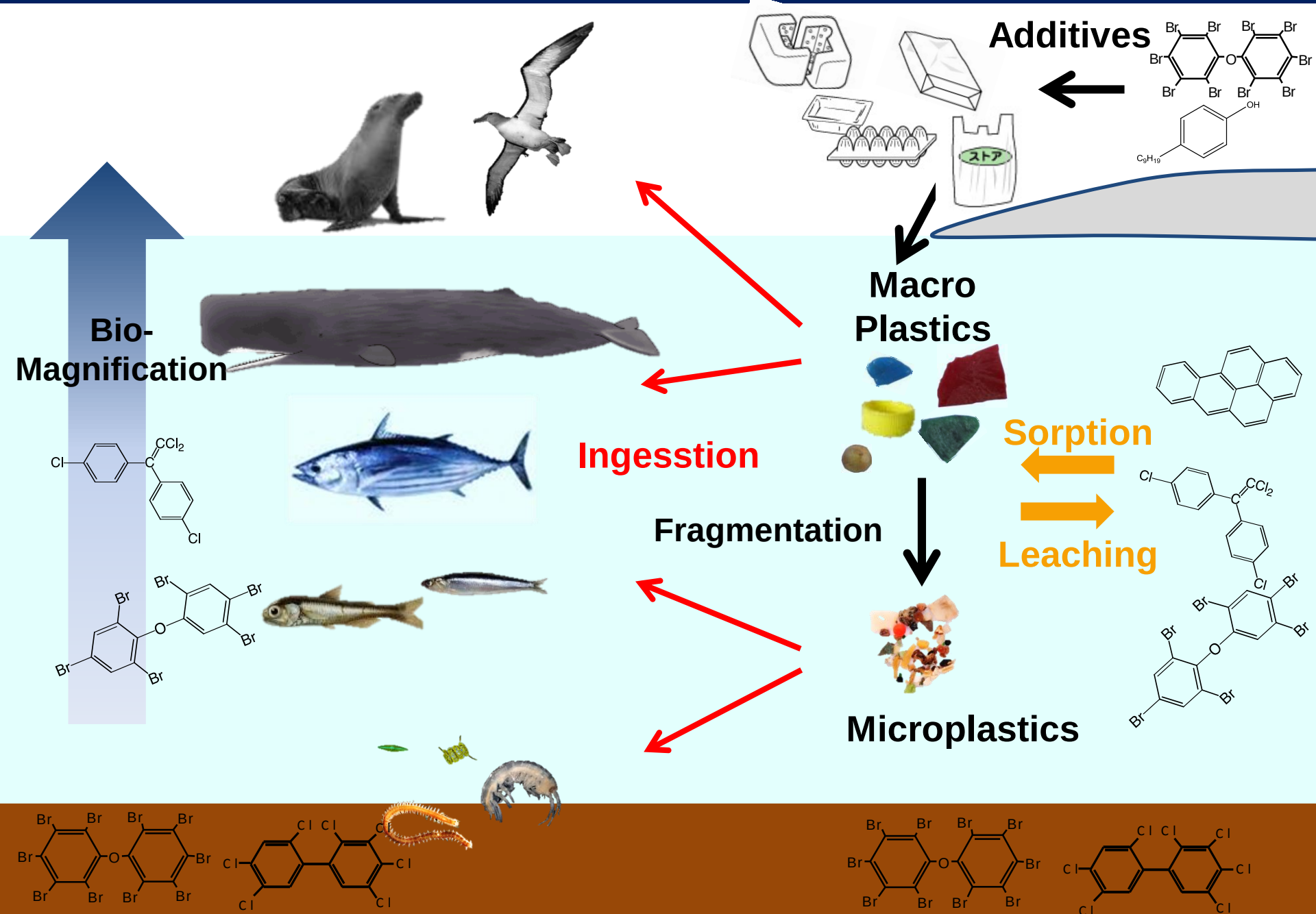


Hexabromocyclododecanes (HBCDs)

Invasion of plastics and **associated chemicals** to ecosystem



Plastics widely contaminate ecosystem with chemicals



GESAMP Working group (2nd phase) on microplastics

April 15th – 17th, 2015

June : G7 Leaders' Declaration

Concern :

Contamination of **seafood** with microplastics and associated chemicals

Topics

- Marine plastic problem and international responses
- Effects of marine plastics on marine organisms
- Solution: No single-use plastic
- Sustainable tourism

Nature, vol. 494, p.169-171, 2013

COMMENT

DIMITAR DILKOFF/AFP/GETTY

Volunteer cleaners negotiate a Bulgarian reservoir jammed with plastics.

Policy : Classify plastic waste as hazardous

Rochman, Chelsea M.; Browne, Mark Anthony; Halpern, Benjamin S.; Hentschel, Brian T.; Hoh, Eunha; Karapanagioti, Hrissi K.; Rios-Mendoza, Lorena M.; Takada, Hideshige; Teh, Swee; Thompson, Richard C.

No single-use plastics

Majority of plastics in marine environment is land-based.
Disposable packaging is dominant item.

Reduction of input of single-use plastic from land is necessary.

3R

Reduce

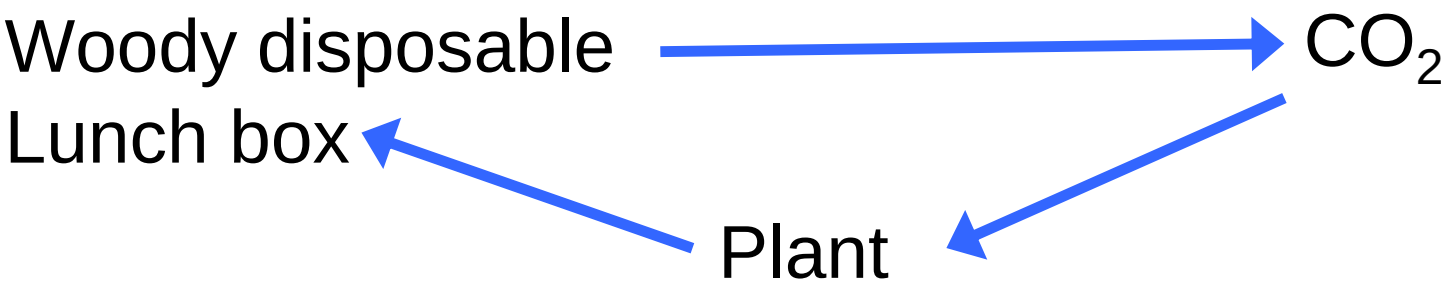
Reuse : non-reusable plastics

Recycle : consumes energy and emits CO_2

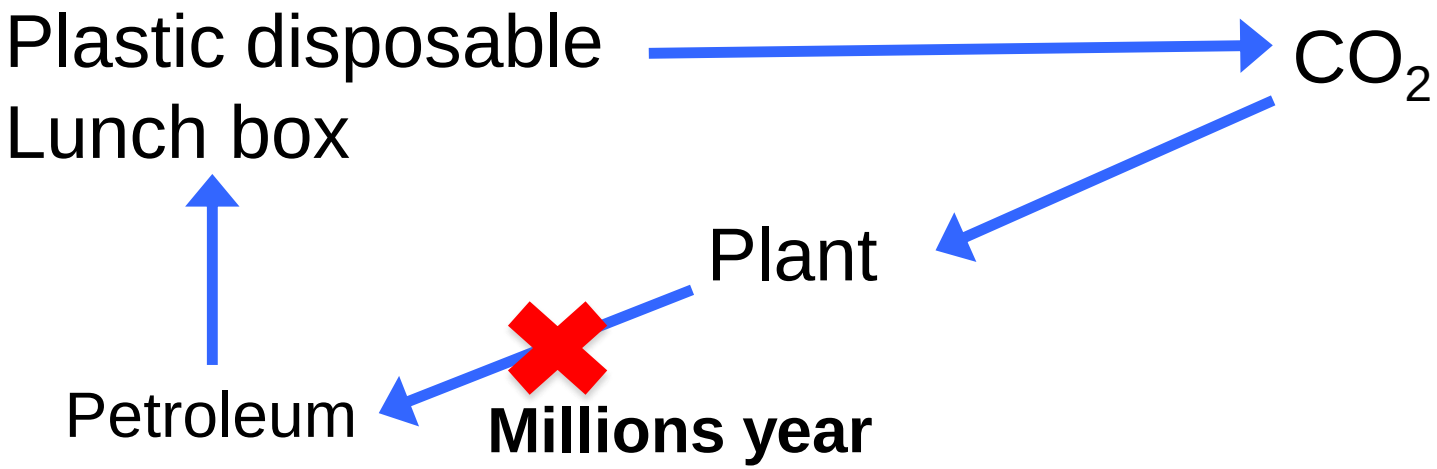
No single-use plastic!

Governmental regulation to reduce excessive plastic packaging is required .

Sustainable



One way, non-sustainable



Sustainable tourism

Reduce the usage of single use plastic

Promote the usage of biomass (paper and wood)

Promote composting

Paradigm shift from “disposability” to “reusability”

Volunteer-based activity : Increase in public awareness regarding plastic pollution in marine environment

To provide basic information to assess the risk of toxic chemicals in microplastics to scientists and policy-makers

Tool to increase public awareness of plastic pollution

Global Monitoring of POPs in marine environments

Hope for future