Microplastic: An emerging threat to marine environment and a new tool for POP monitoring

Shige Takada

（Tokyo University of Agriculture and Technology）

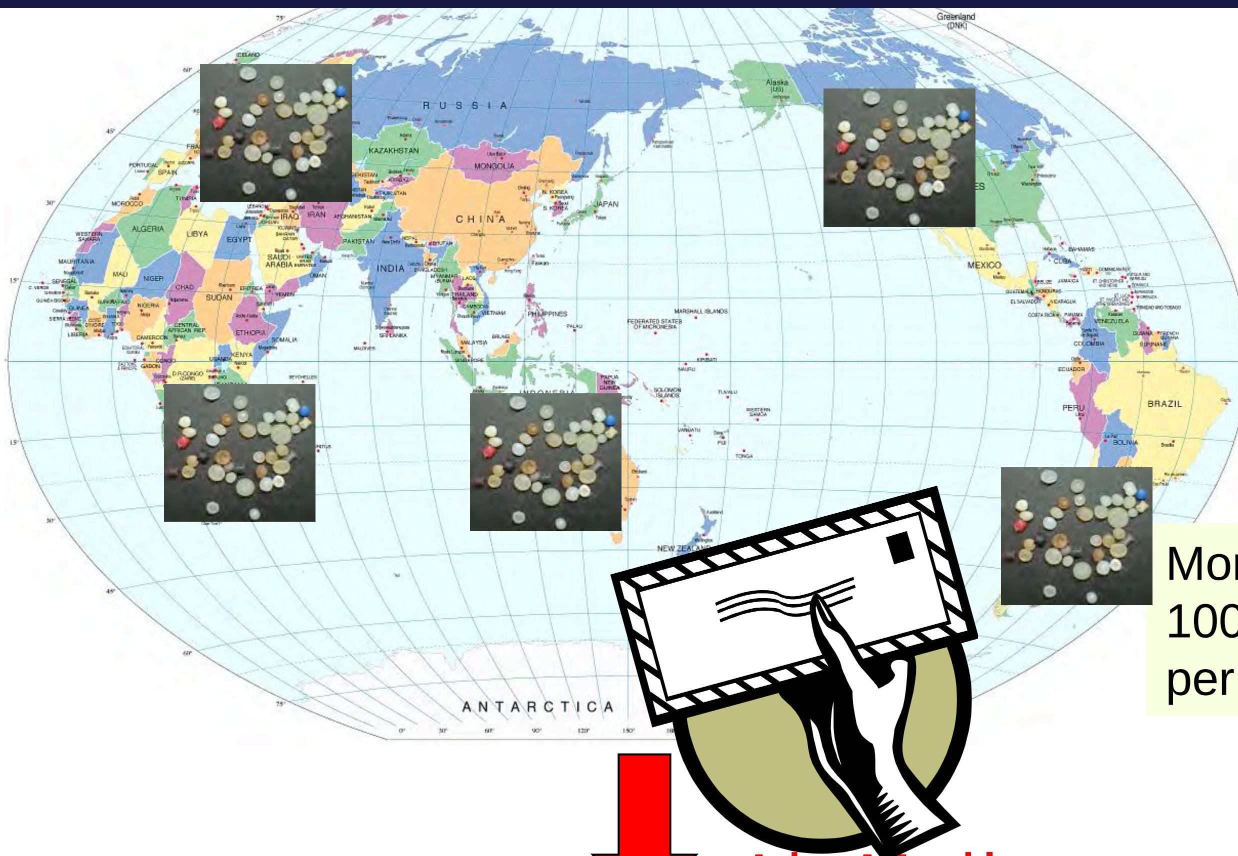
Topics

International Pellet Watch : new indicator of marine pollution

Detection of microplastics in seafood and
potential transfer of microplastic-associated chemicals to
seafood and human

International Pellet Watch

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



Since 2005

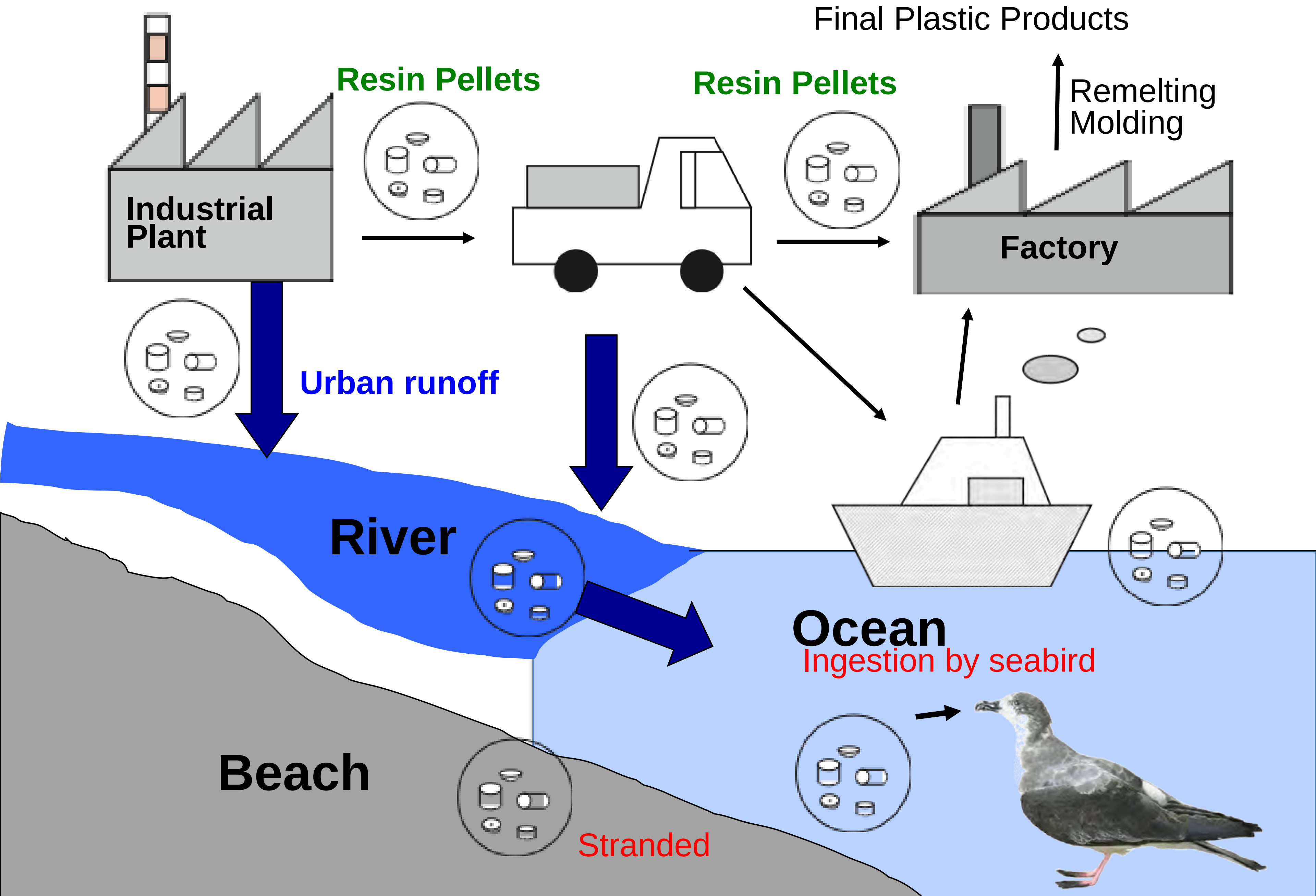
More than 50 pieces (~ 100 pieces) per one location

Air Mail

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

Plastic Resin Pellets

Resin pellets, industrial feedstock of user plastics, are spilled during transport and manufacturing and they are widely distributed in the ocean



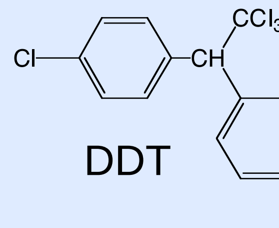
Plastic resin pellets on high-tide line on our beaches

Plastics accumulate organic pollutants from seawater

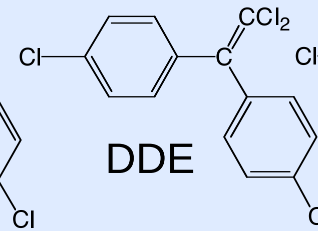
PCBs

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

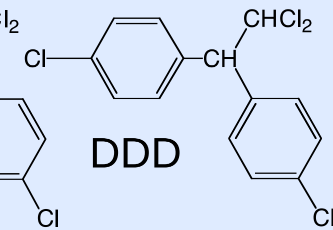
DDTs



DDT



DDE



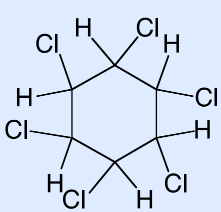
DDD

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

adsorption from ambient seawater

Plastics

HCH



- Insecticide

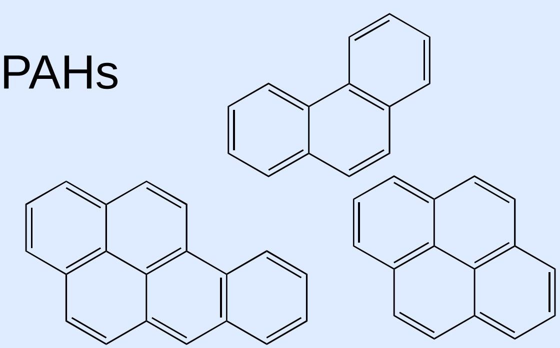
$-(CH_2-CH_2)_n-$

Polyethylene (PE)

$-(CH_2-CH(CH_3))_n-$

Polyprorylene (PP)

PAHs



Mato *et al*. (2001), *ES&T*

Pellets accumulate POPs from seawater

PCBs

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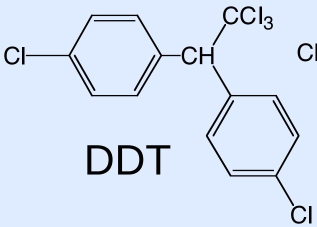
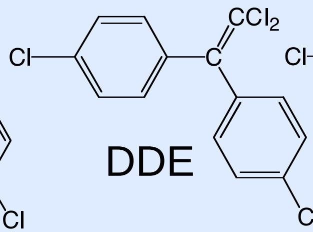
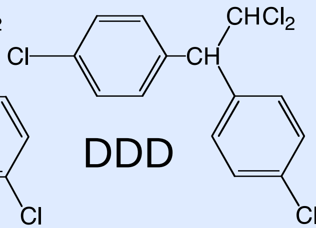
DDTs



DDT



DDE



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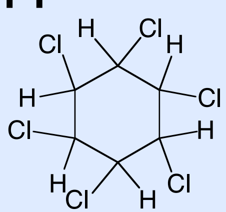
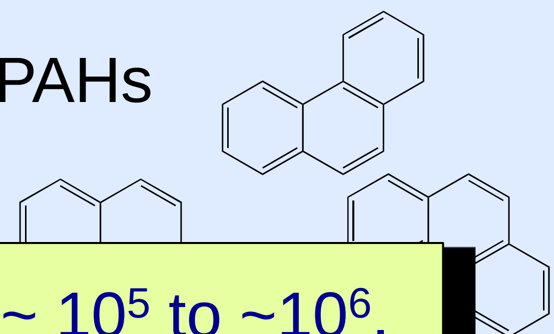


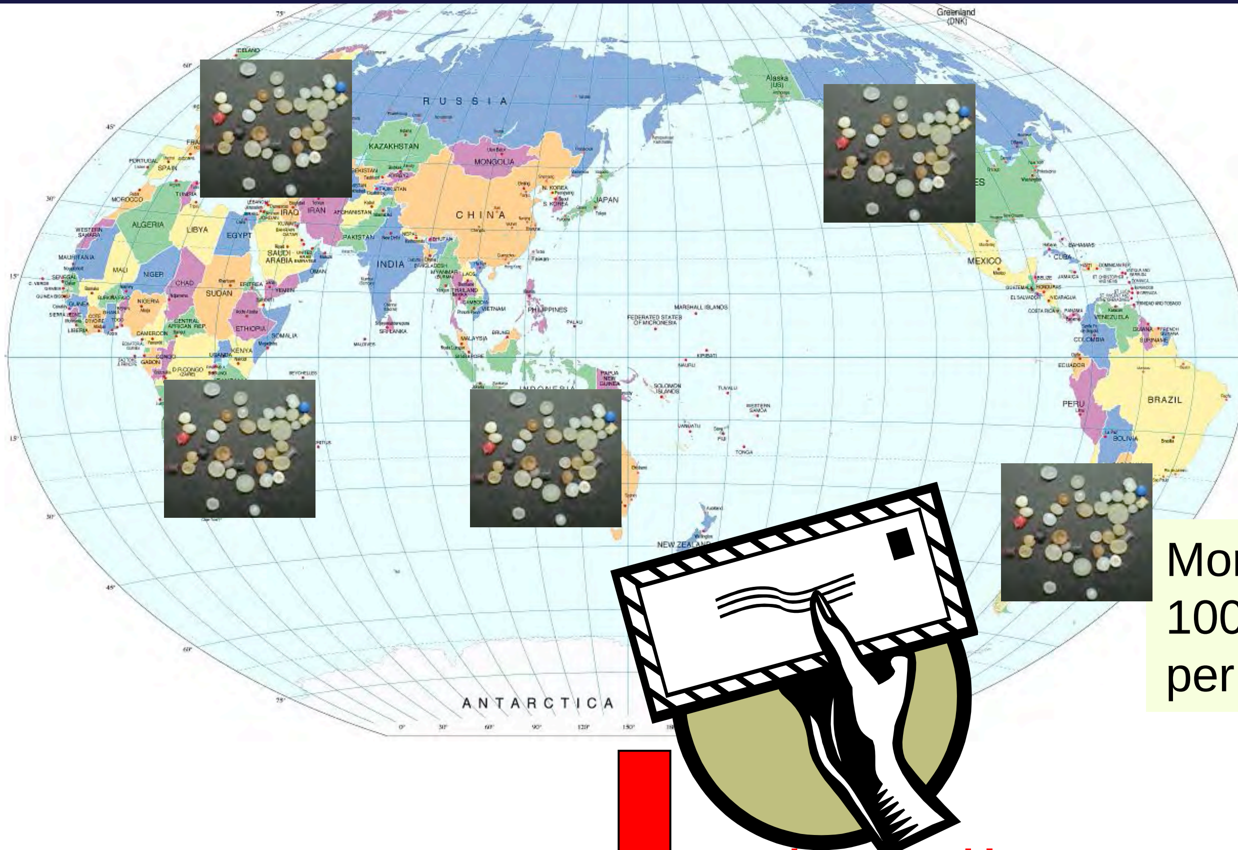
PAHs



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



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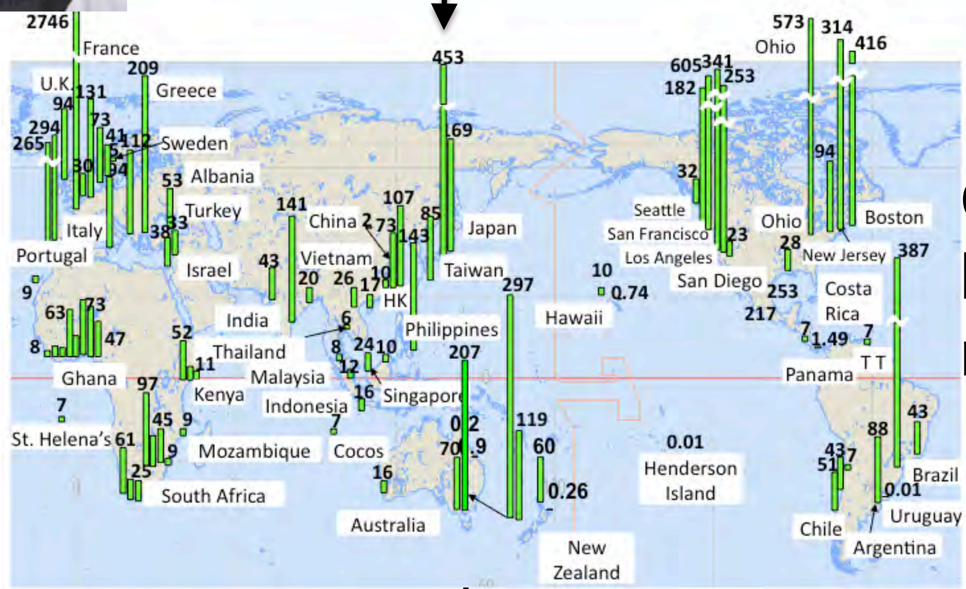
Analysis for persistent organic pollutants (POPs)

Chemical Analysis

Status of Global pollution

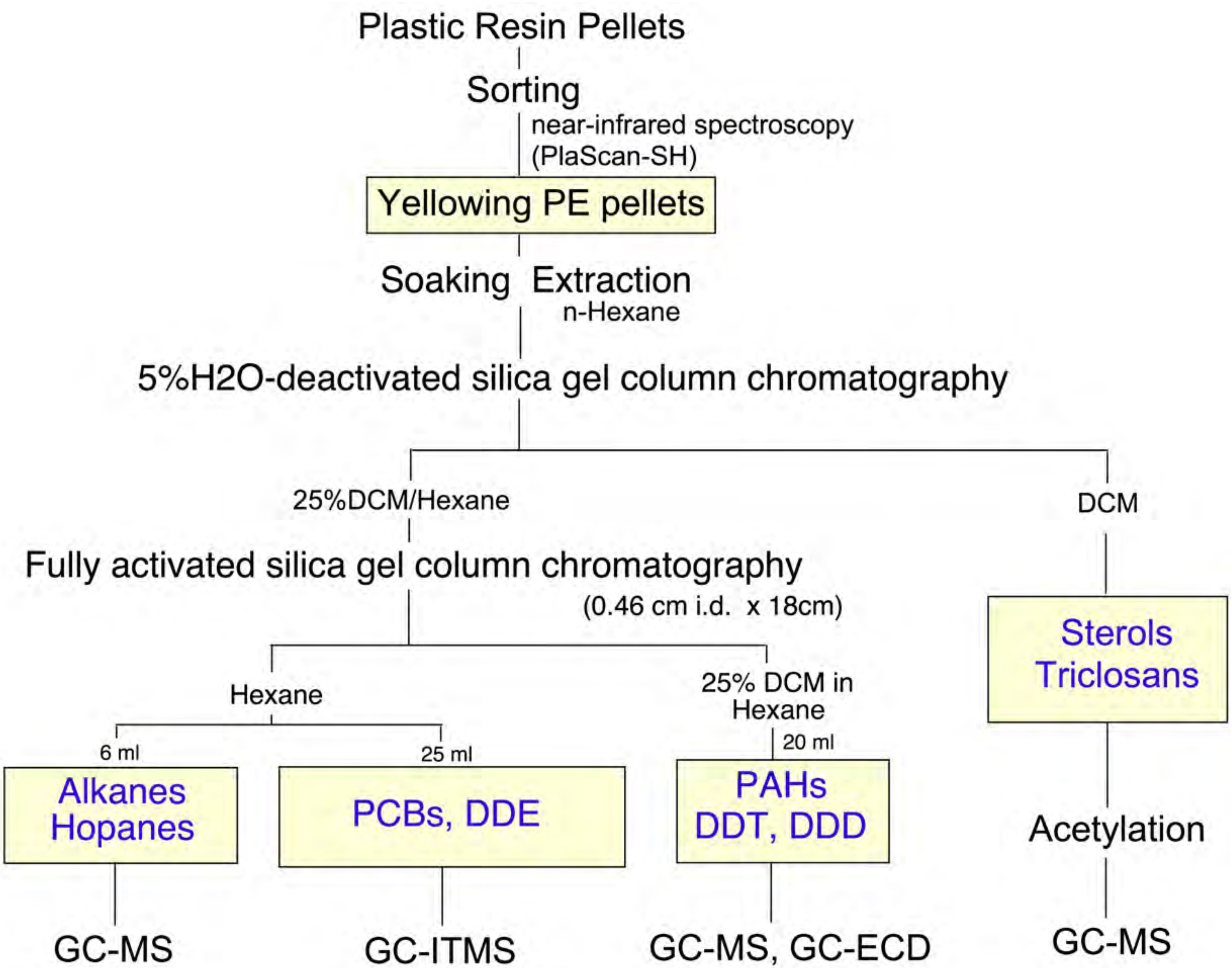


Chemical hazardousness of marine plastics

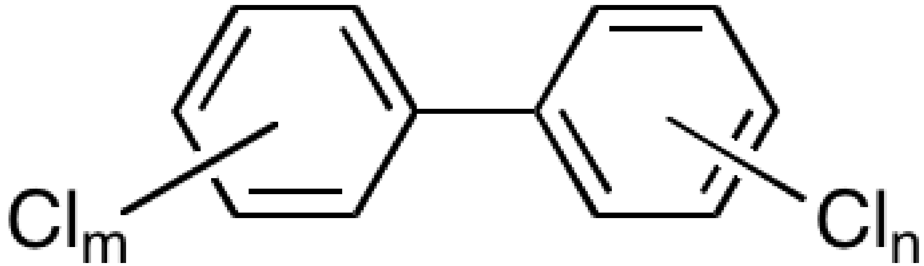
- **Feed the data** back to the collaborators via e-mail
- **Releasing** the results on **web** http://**www.pelletwatch.org/**

200 samples from 40 countries

Analytical Procedure of POPs, PAHs, sewage marker sterols, and triclosans in Pellets



Polychlorinated biphenyls (PCBs)



$m + n = 1 - 10$

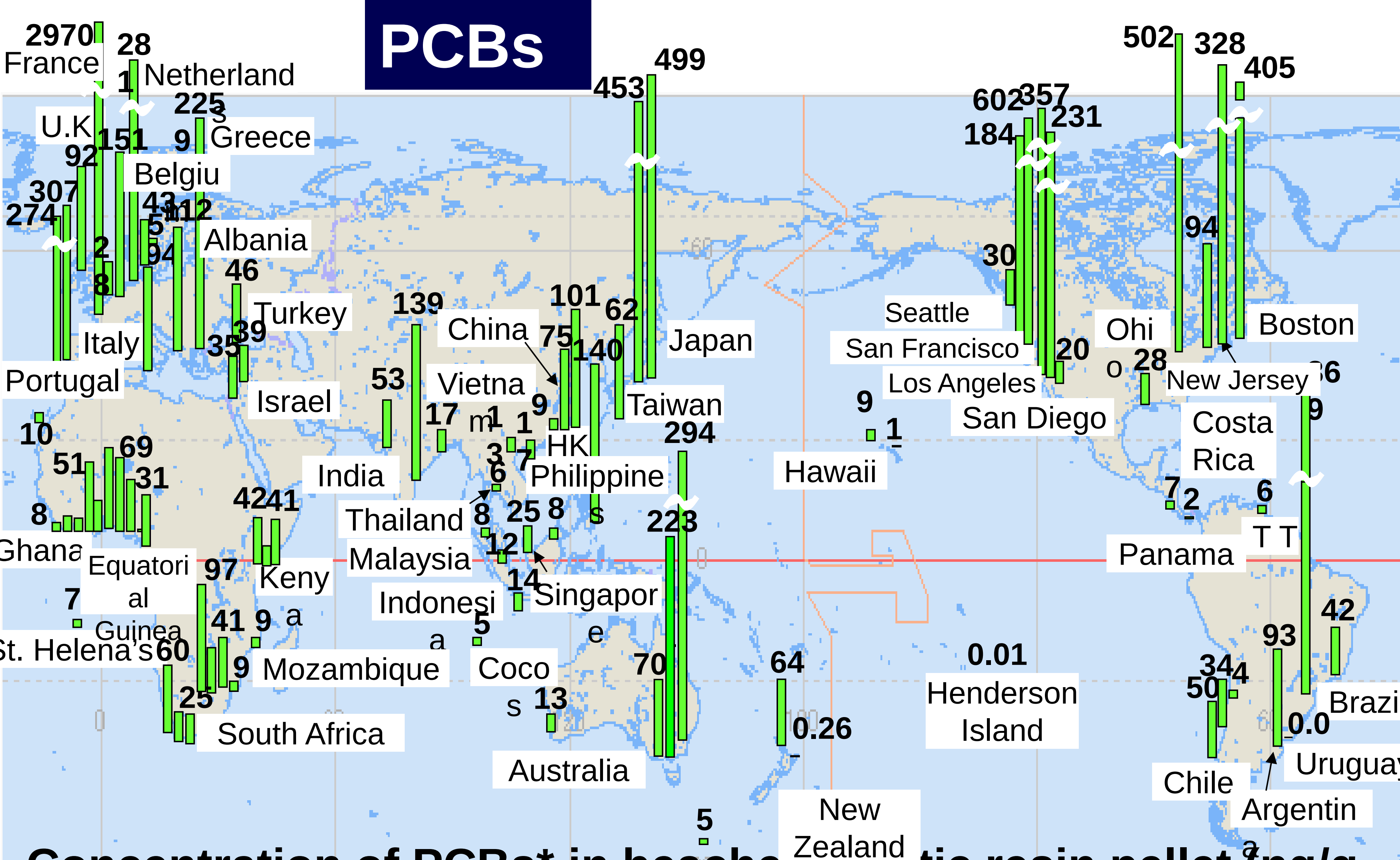
Commercial PCBs mixtures were used in a wide variety of applications, including

- Dielectric fluids in capacitors and transformers
- Heat transfer fluid
- Copying paper
- Carbonless copy paper
- Adhesives
- Sealant

PCBs were used from 1950s to early 1970s in industrialized countries.

Their usage was banned in 1970s

PCBs



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

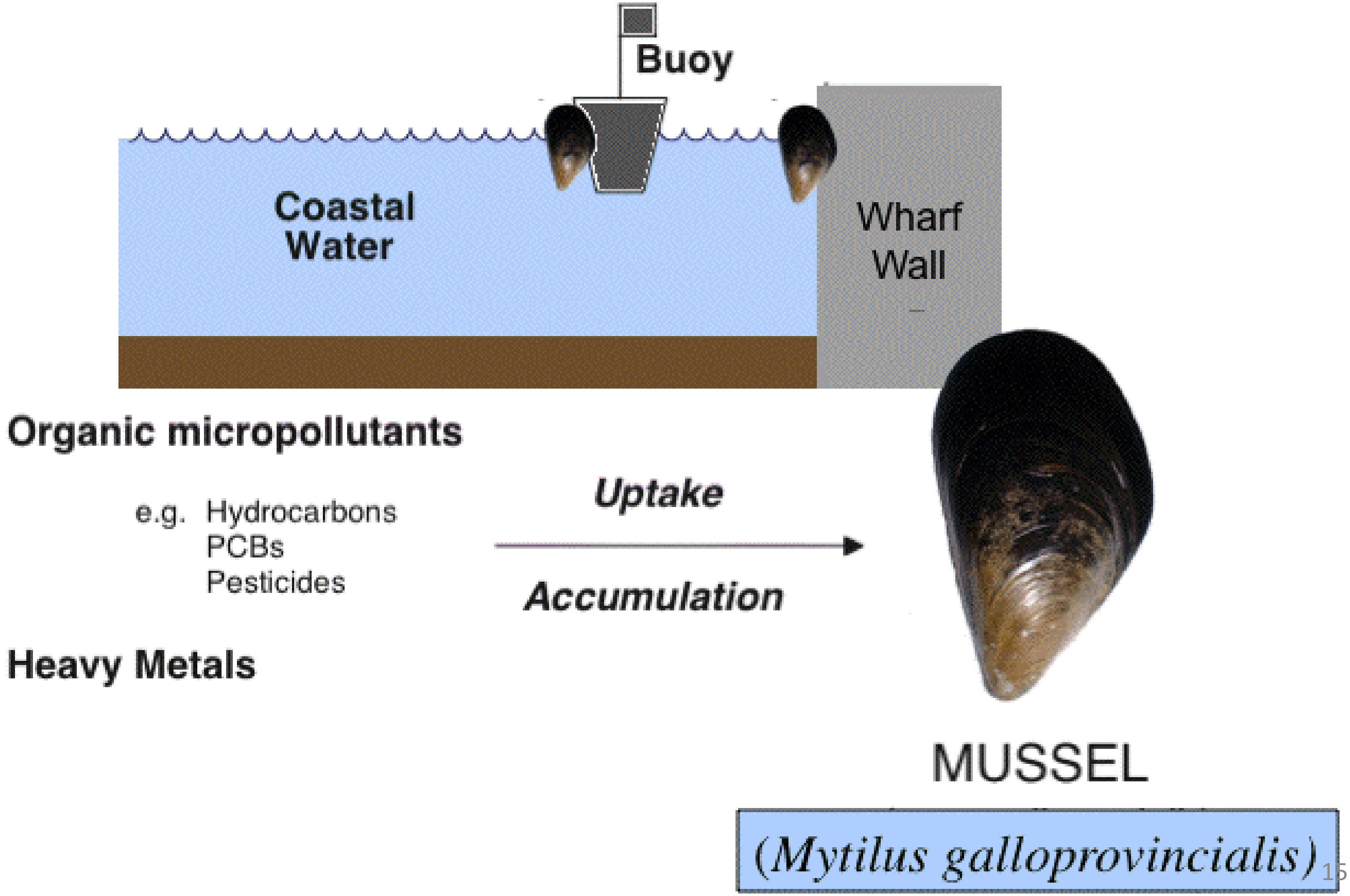
*sum of concentrations of CB#66, 101, 110, 149, 118, 105, 153, 138, 128, 187, 180, 170, 206

Measured by Polaris Q (Thermo Fisher Scientific)

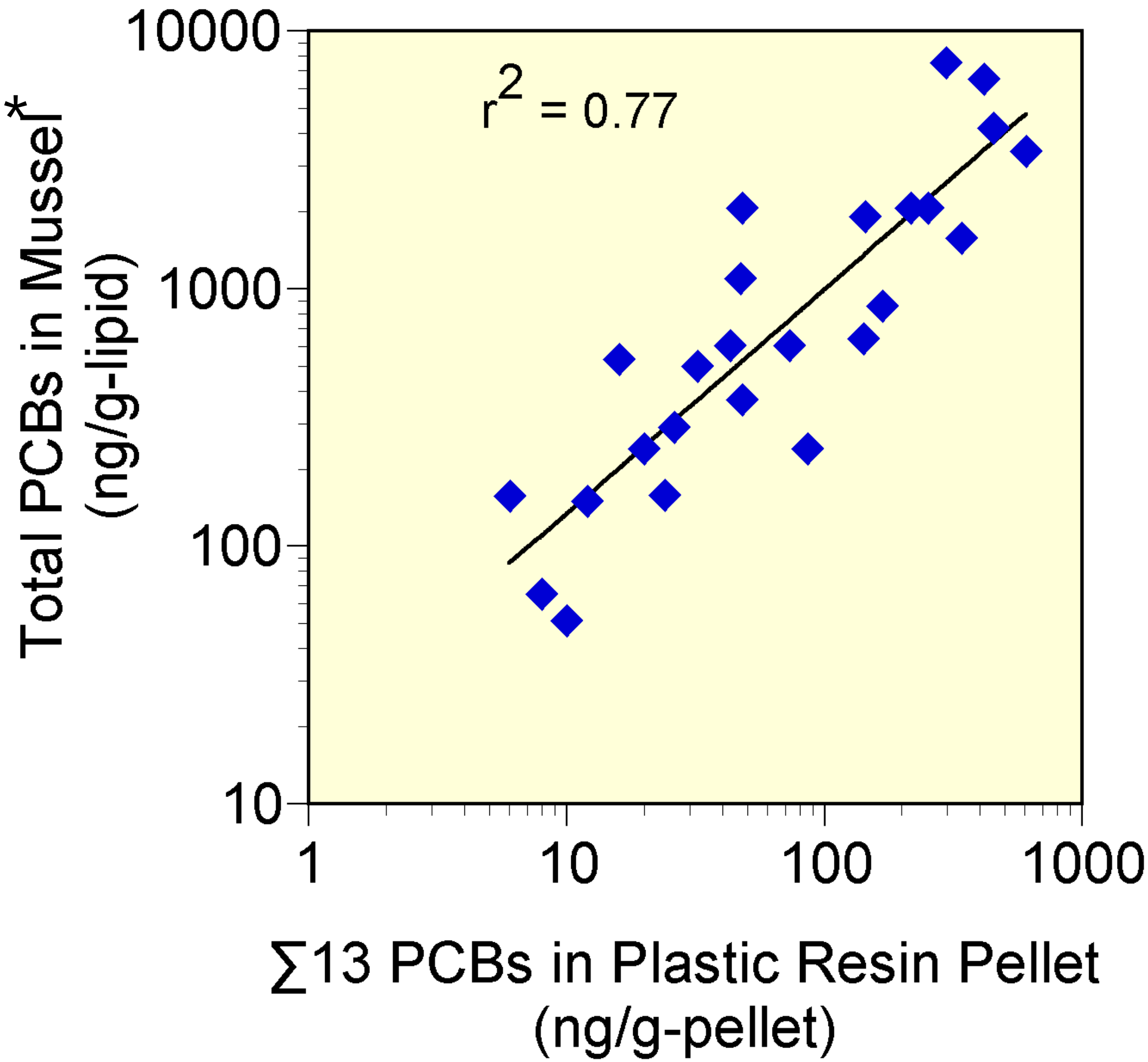
Mussel Watch : Traditional Monitoring of pollution in coastal waters

Mussel Watch

Monitoring methodology of coastal pollution using bivalves as sentinel organism

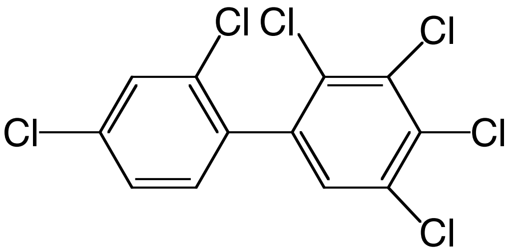


Correlation of PCB concentrations between beached pellets and mussels

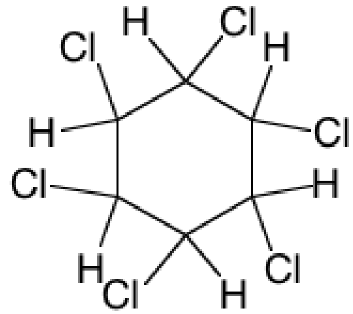


*Data on mussels : after Yamaguchi et al. 2000, Monirith et al. 2003, NOAA 2007)

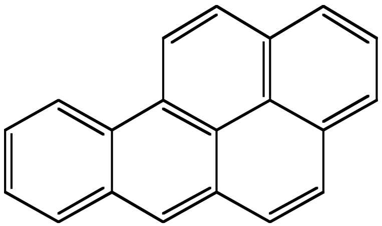
IPW targets on legacy and emerging pollutants



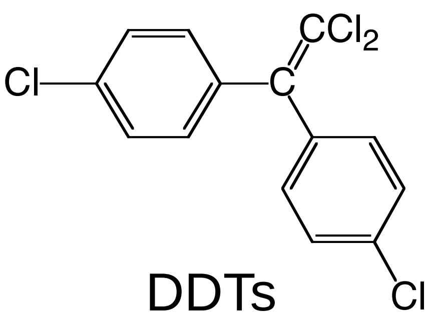
Polychlorinated biphenyl (PCBs)



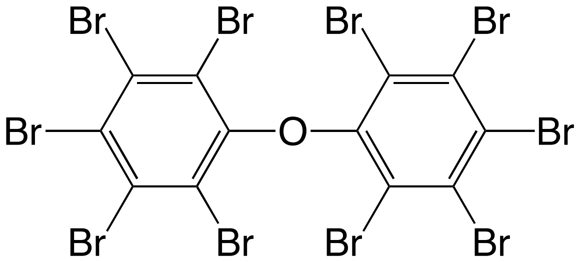
HCHs



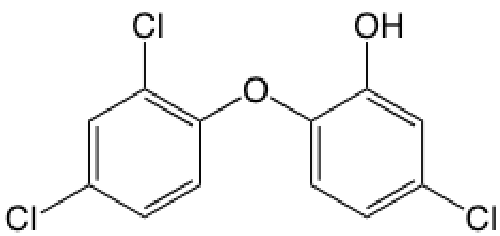
Polycyclic aromatic hydrocarbons (PAHs)



DDTs



Polybrominated diphenyl ethers (PBDEs)



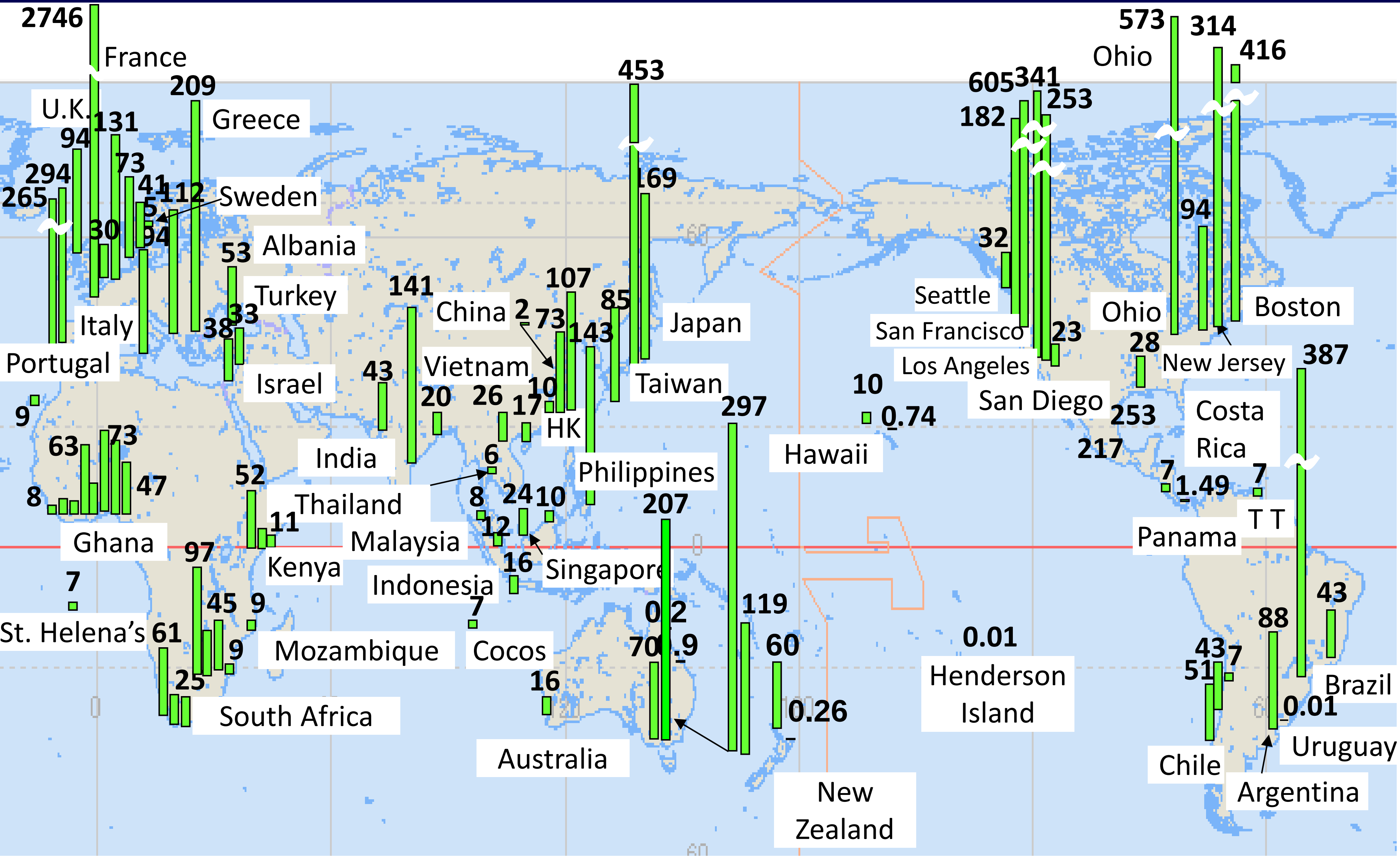
Triclosan (TCS)

Topics

International Pellet Watch : new indicator of marine pollution

Detection of microplastics in seafood and
potential transfer of microplastic-associated chemicals to seafood and human

International Pellet Watch tells us that marine plastics carry hazardous chemicals in marine environments



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

Sorption of chemicals occurs not only on pellets but on fragments

Environmental Science & Technology

Article

pubs.acs.org/est

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

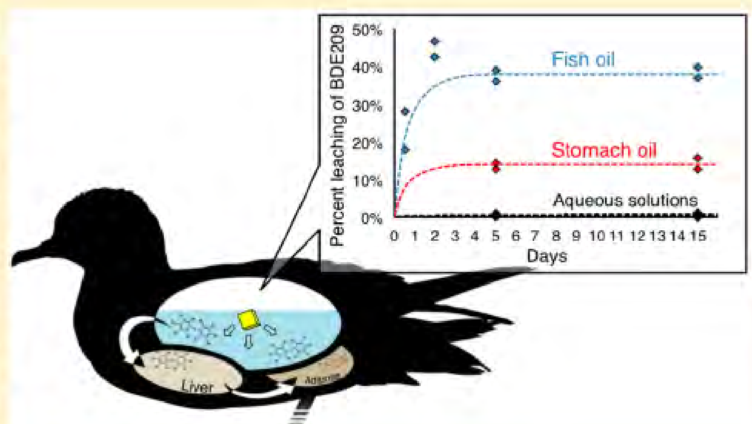
Kosuke Tanaka,[†] Hideshige Takada,[*,†] Rei Yamashita,[†] Kaoruko Mizukawa,[†] Masa-aki Fukuwaka,[‡] and Yutaka Watanuki[§]

[†]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

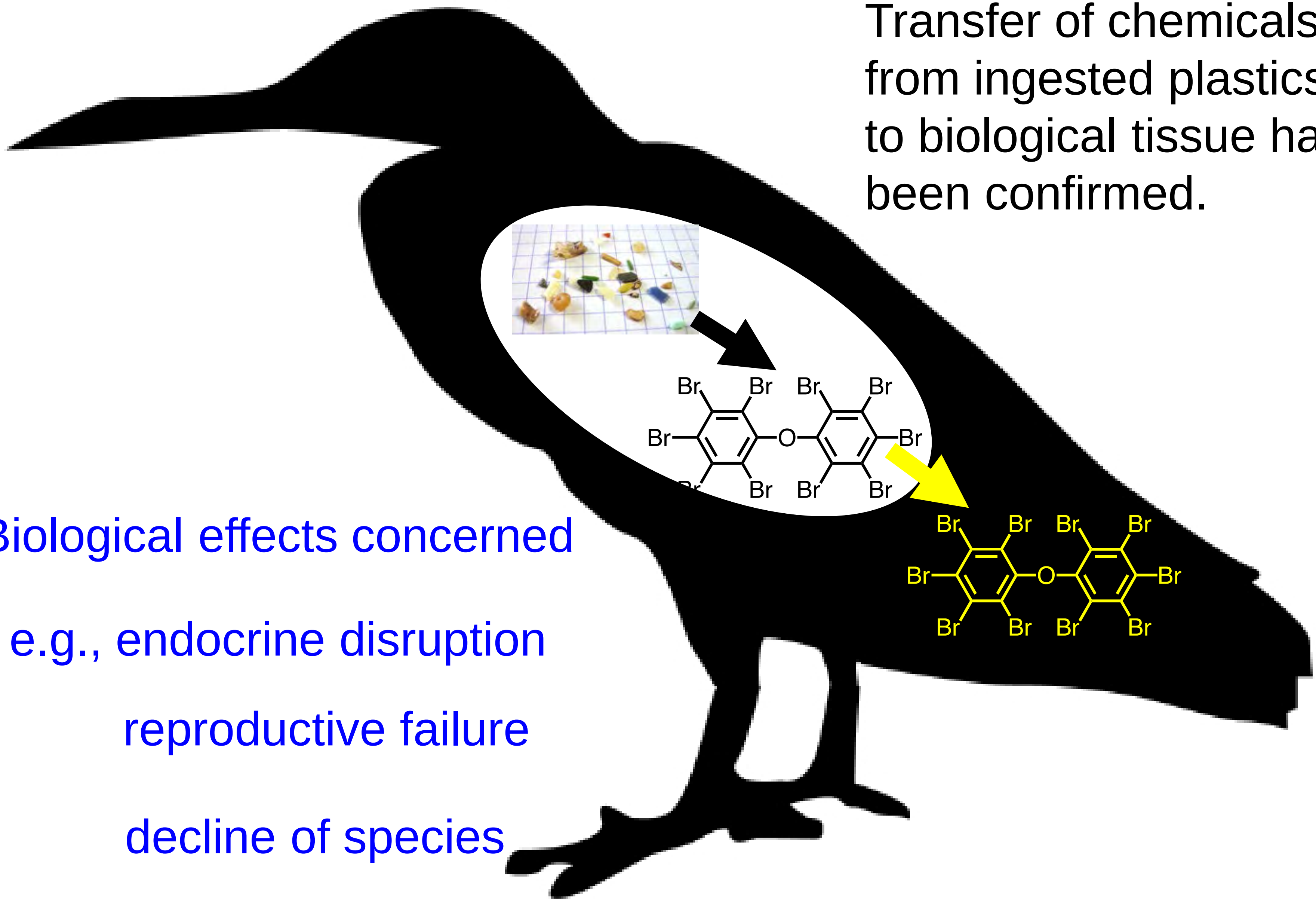
Supporting Information



ABSTRACT: Our previous study suggested the transfer of polybrominated diphenyl ether (PBDE) flame retardants from ingested plastics to seabirds' tissues. To understand how the PBDEs are transferred, we studied leaching from plastics into digestive fluids. We hypothesized that stomach oil, which is present in the digestive tract of birds in the order Procellariiformes, acts as an organic solvent, facilitating the leaching of hydrophobic chemicals. Pieces of plastic compounded with deca-BDE were soaked in several leaching solutions. Trace amounts were leached into distilled water, seawater, and acidic pepsin solution. In contrast, over 20 times as much material was leached into stomach oil, and over 50 times as much into fish oil (a major component of stomach oil). Analysis of abdominal adipose, liver tissue, and ingested plastics from 18 wild seabirds collected from the North Pacific Ocean showed the occurrence of deca-BDE or hexa-BDEs in both the tissues and the ingested plastics in three of the birds, suggesting transfer from the plastic to the tissues. In birds with BDE209 in their tissues, the dominance of BDE207 over other nona-BDE isomers suggested biological debromination at the meta position. Model calculation of PBDE exposure to birds based on the results of the leaching experiments combined with field observations suggested the dominance of plastic-mediated internal exposure to BDE209 over exposure via prey.

Transfer of chemicals from ingested plastics to biological tissue

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



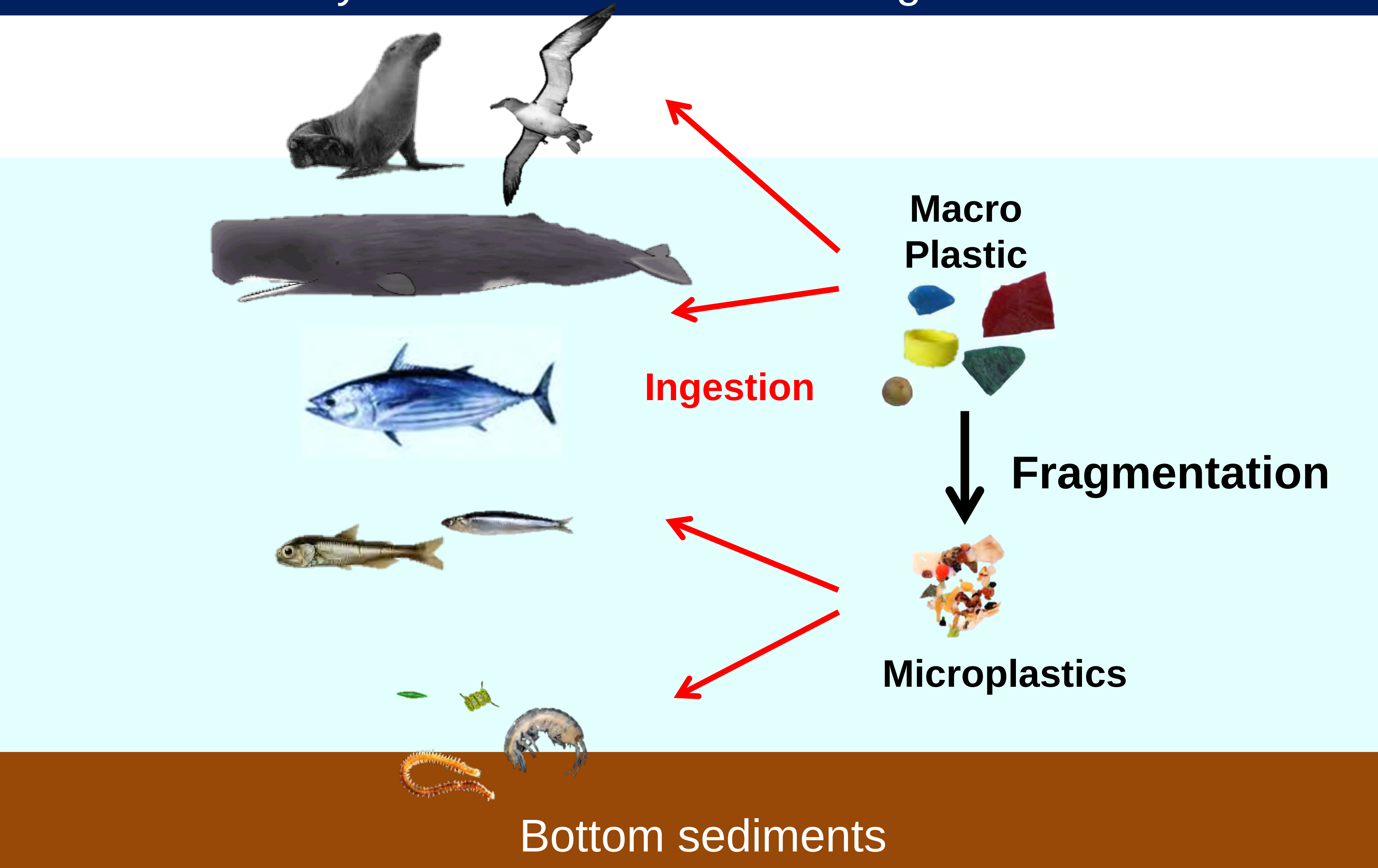
Biological effects concerned

e.g., endocrine disruption

reproductive failure

decline of species

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 lower-trophic-level organisms

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

Ingestion of Microplastics by Zooplankton in the Northeast Pacific Ocean

Jean-Pierre W. Desforges[1] · Moira Galbraith[2] · Peter S. Ross[1]

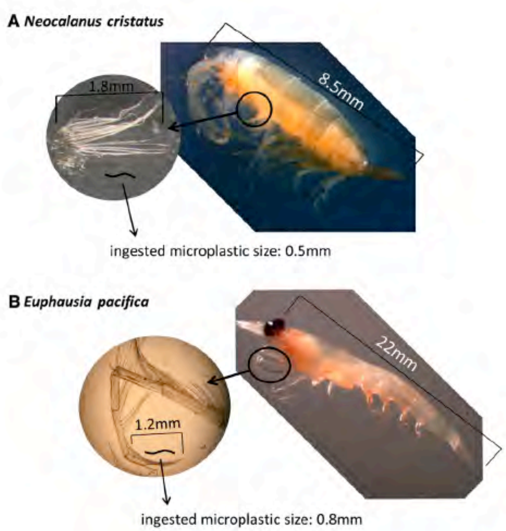


Fig. 2 The feeding appendage anatomy of **a** *N. cristatus* and **b** *E. pacifica* suggest that the sizes of ingested microplastic particles were within the physical limits of mouth gape and handling capacity of setae. The average microplastic particle size detected in this study is shown in relation to the size of setae for both zooplankton species

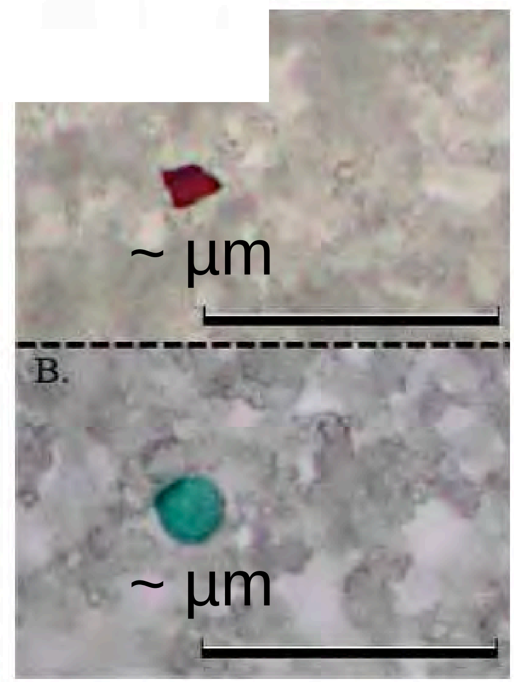


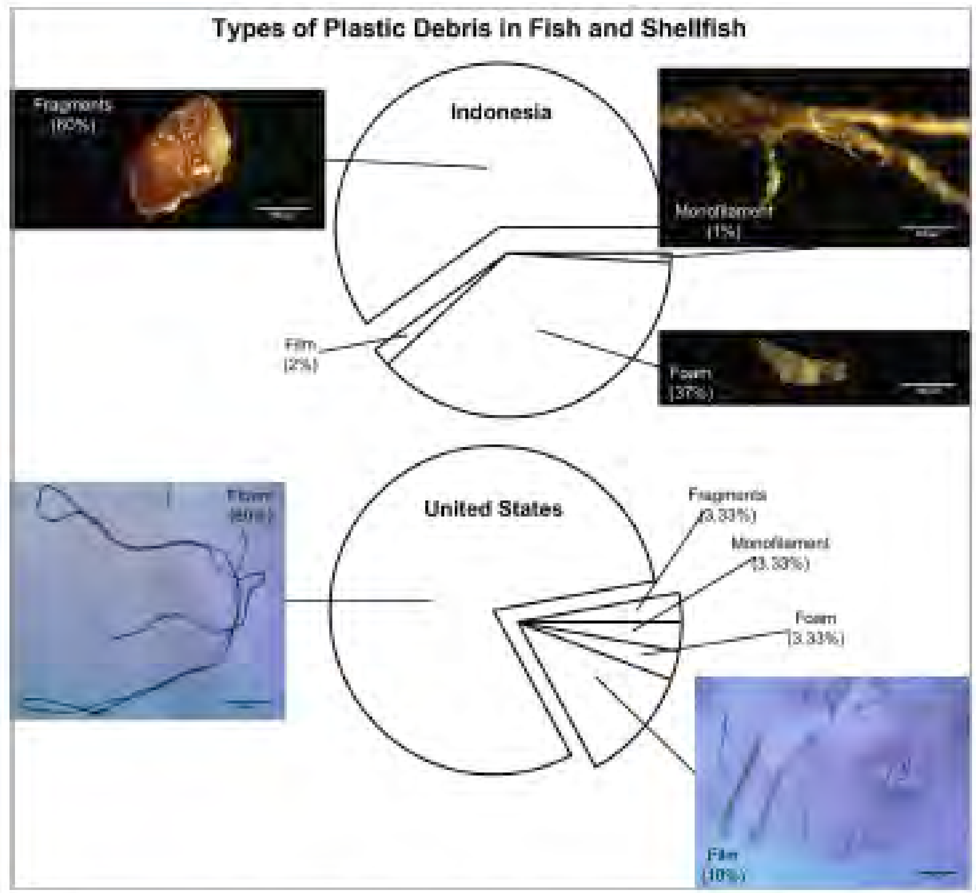
Fig. 1. Microplastics detected in the acid digested *Mytilus edulis* and *Crassostrea gigas*. A. Red particle recovered from *Mytilus edulis*; B. Green sphere detected in the soft tissue of *Crassostrea gigas*. (Scale bar: 50 µm). (For interpretation of the references to colour in this figure legend,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

OPEN

Anthropogenic debris in seafood: Plastic debris and fibers from textiles in fish and bivalves sold for human consumptio

Received: 01 April 2015
cepted: 25 August 2015
ed: 24 September 2015

Chelsea M. Rochman[1], Akbar Tahir[2], Susan L. Willia
Jeffrey T. Miller[4], Foo-Ching Teh[3], Shinta Werorilan



SCIENTIFIC REPORTS

Figure 3. Types of anthropogenic debris in market fish products sampled from Indonesia and the United States. The pie charts above show the percentage of each type (i.e. plastic fragments, fibers, plastic film, plastic foam and plastic monofilament) of anthropogenic debris found across all fish sampled from Indonesia (top) and the United States (bottom). Images show examples of each type of debris found. Scale bars on all pictures are set at 500μm.

Method

Dissection

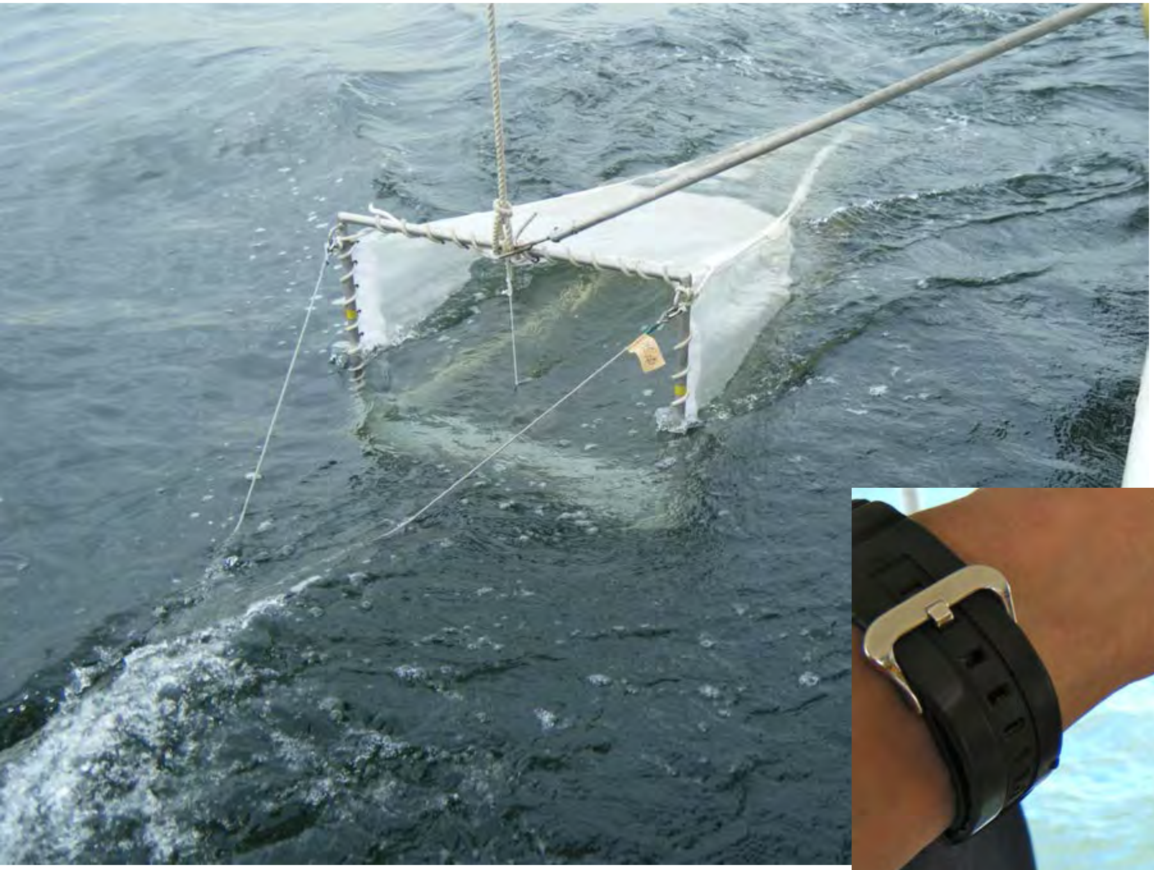
Stomach contents

Hydrolysis with KOH

Identification of polymer type by using FTIR

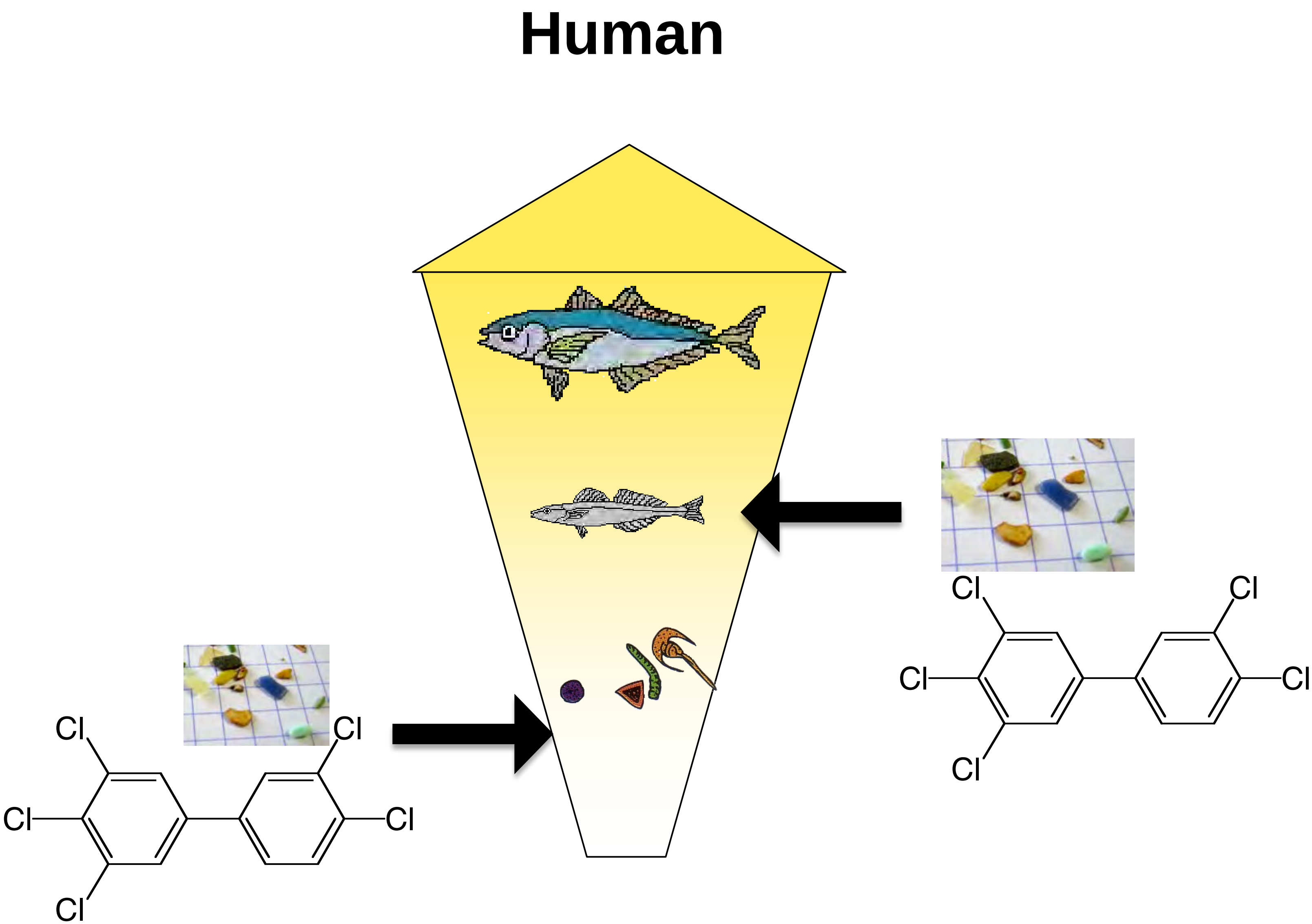
Collecting microplastics in seawater of Tokyo Bay

Collecting microplastics in seawater of Tokyo Bay

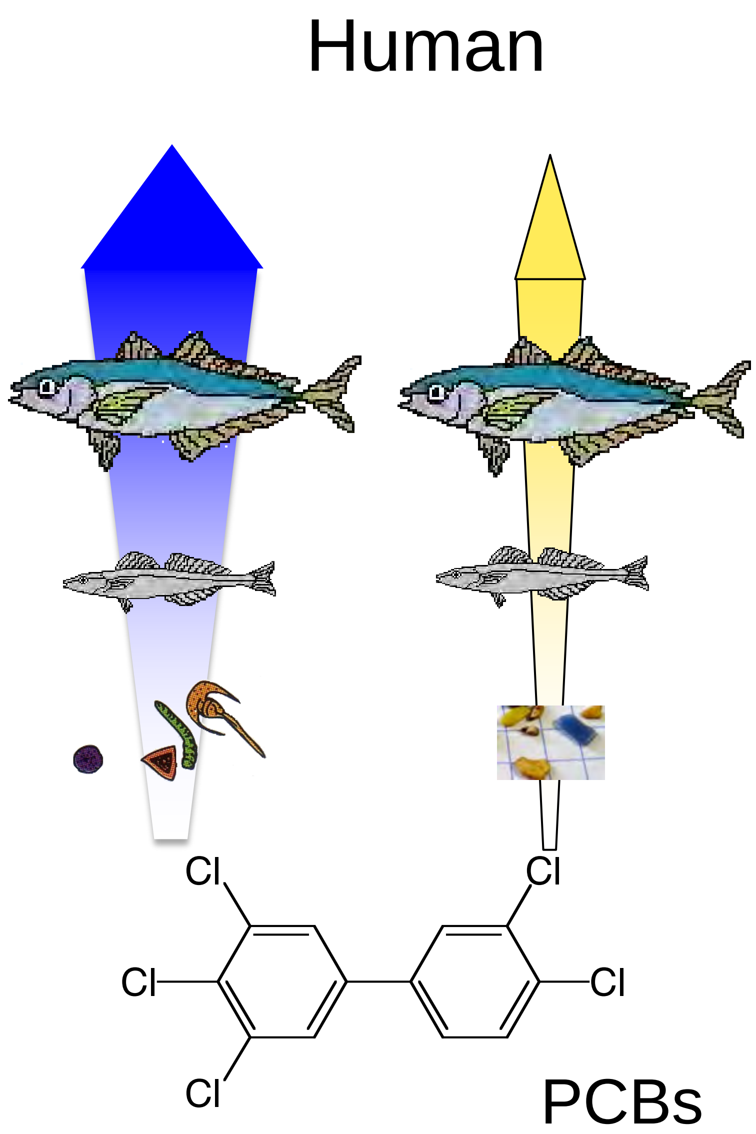


Microplastics in seawater of Tokyo Bay

Invasion of plastics and associated chemicals to ecosystem



Marine organisms are exposed to hazardous chemicals through their natural prey and microplastics



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.

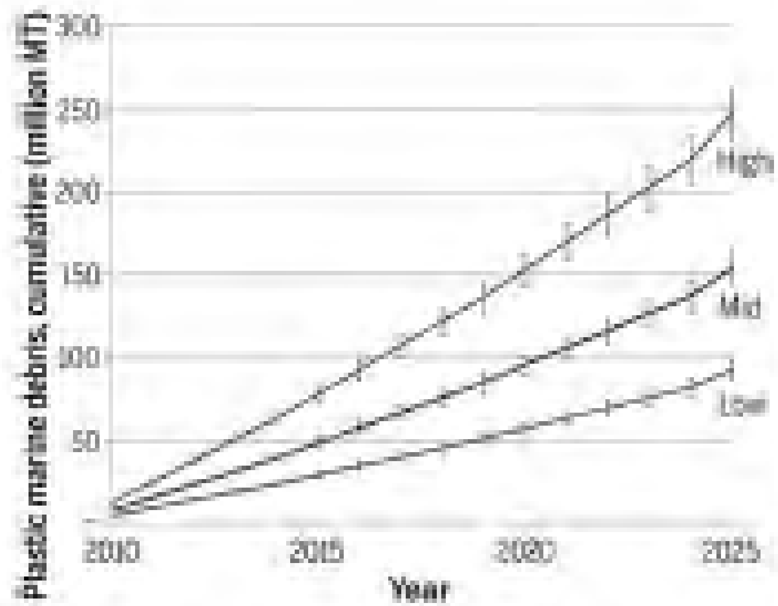
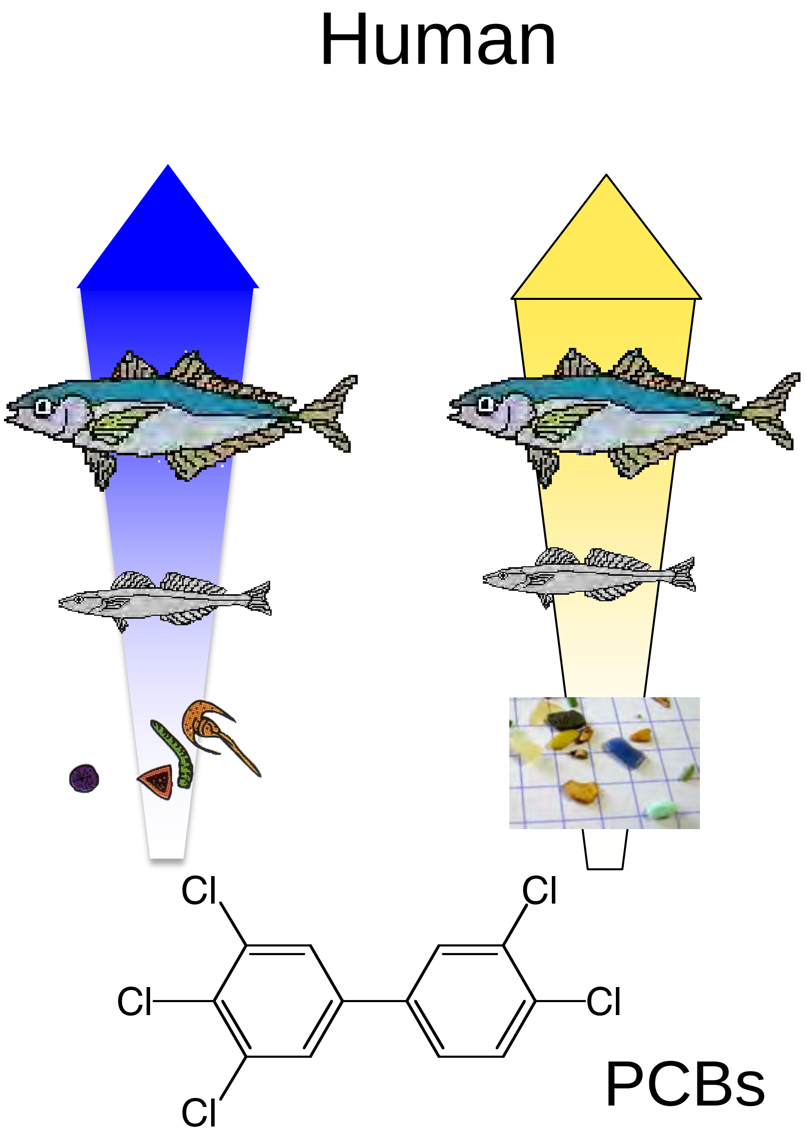


Fig. 2. Estimated mass of mismanaged plastic waste (millions of metric tons) input to the ocean by populations living within 50 km of a coast in 192 countries, plotted as a cumulative sum from 2010 to 2025. Estimates reflect assumed conversion rates of mismanaged plastic waste to marine debris (high,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

Marine organisms are exposed to hazardous chemicals through their natural prey and microplastics



Conclusion

Plastic resin pellets are a promising indicator of legacy and emerging hydrophobic pollutants.

Microplastics carry POPs to seafood

Questions

Importance of microplastic-associated path of POPs to food chain

We should know

- Concentrations of POPs in microplastics and their variations
- Concentrations of POPs in natural prey (e.g., plankton)
- Amounts of microplastics in the organisms
- Retention time of microplatics in the organisms
- Leaching rate of POPs from microplastics to digestive fluid