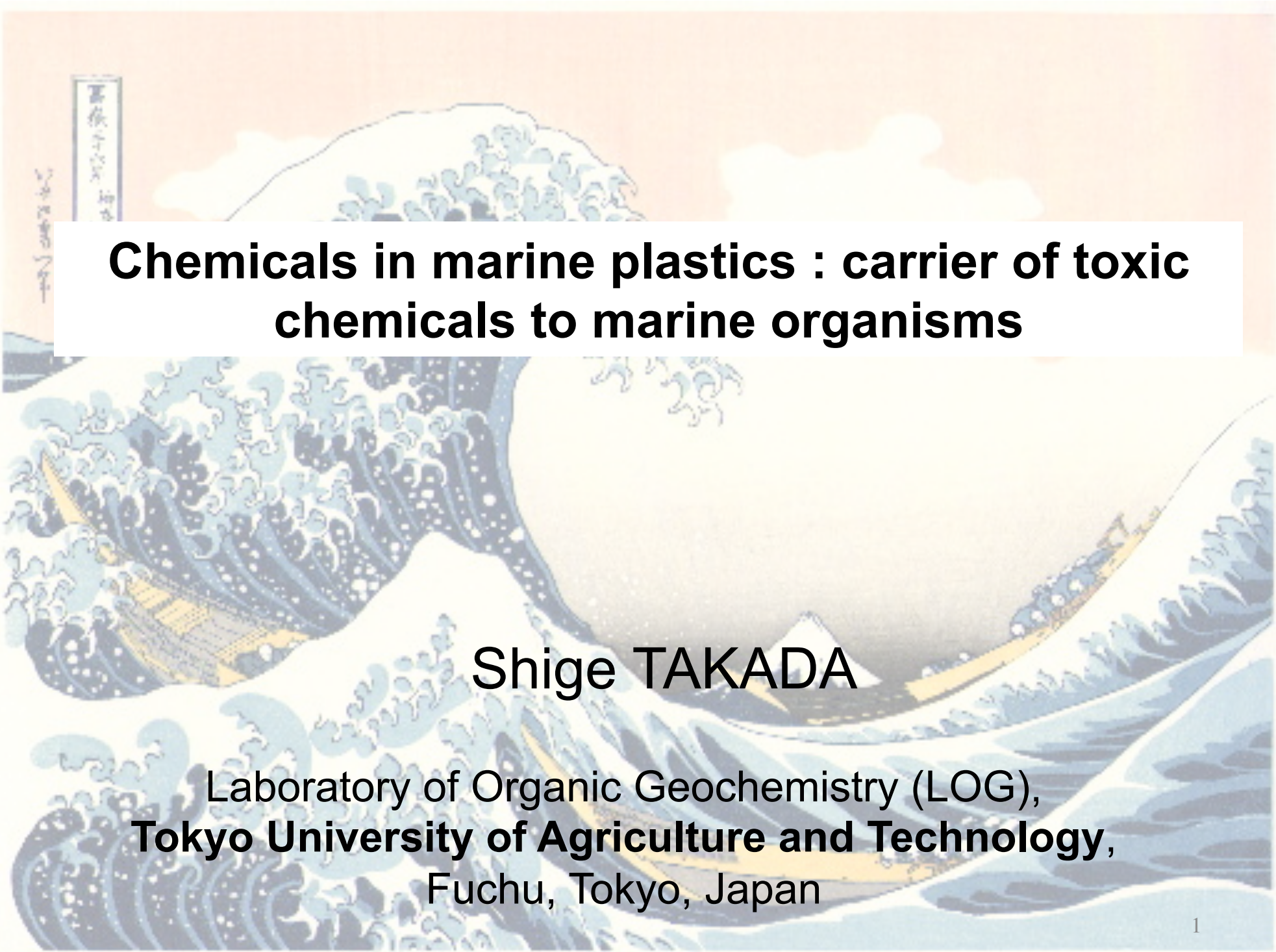


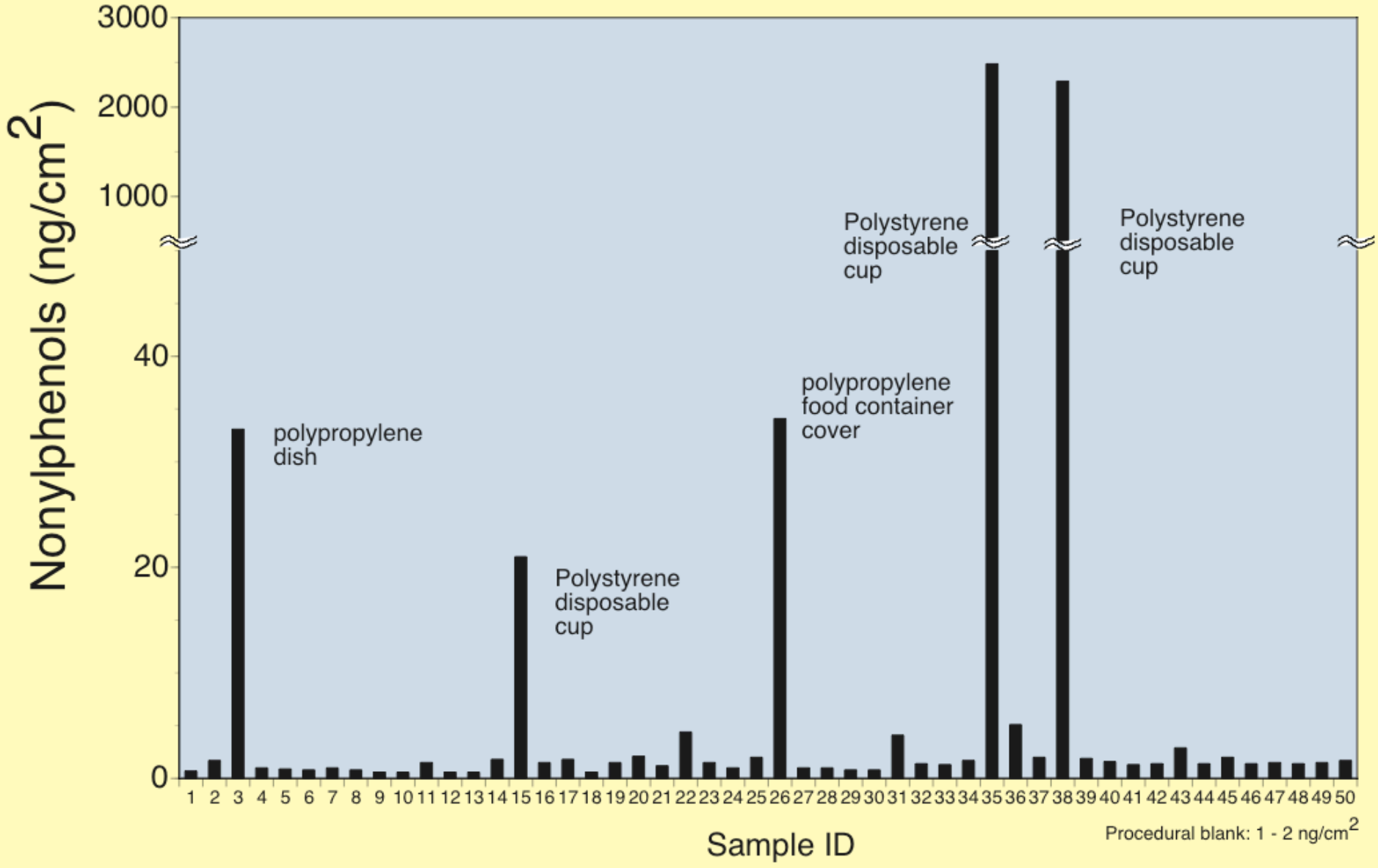
Chemicals in marine plastics : carrier of toxic chemicals to marine organisms

Shige TAKADA

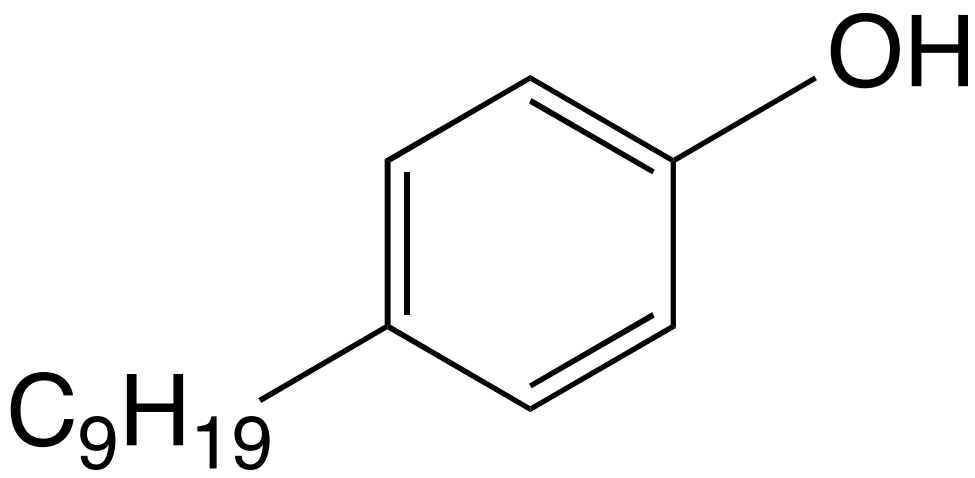
Laboratory of Organic Geochemistry (LOG),
Tokyo University of Agriculture and Technology,
Fuchu, Tokyo, Japan

Flying Endocrine Disrupters?

Nonylphenols released from plastic cups, dishes and food containers



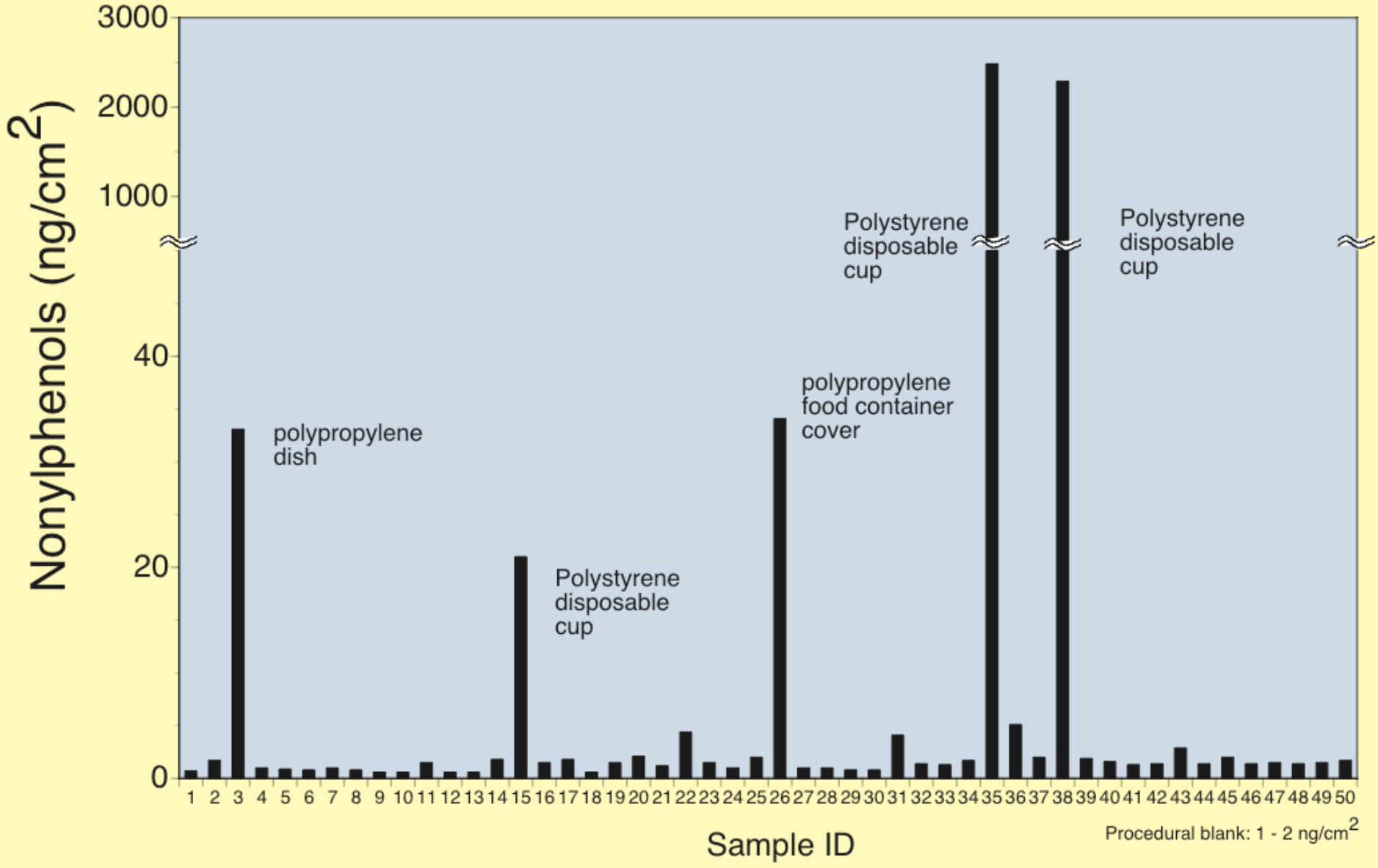
Nonylphenol : Endocrine disrupting chemicals



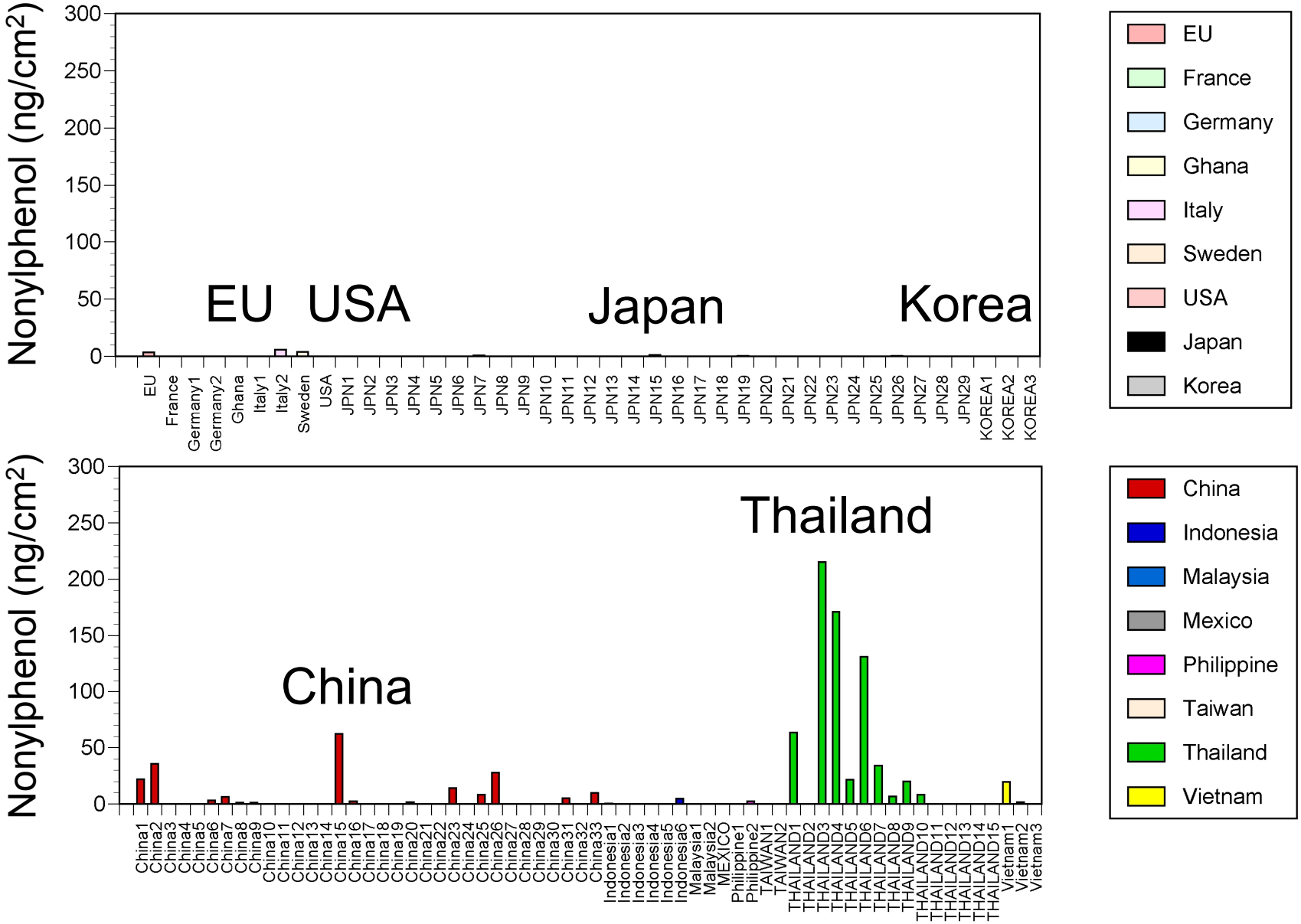
Additives to plastic

Antioxidants
Antistatic agents

Nonylphenols released from plastic cups, dishes and food containers

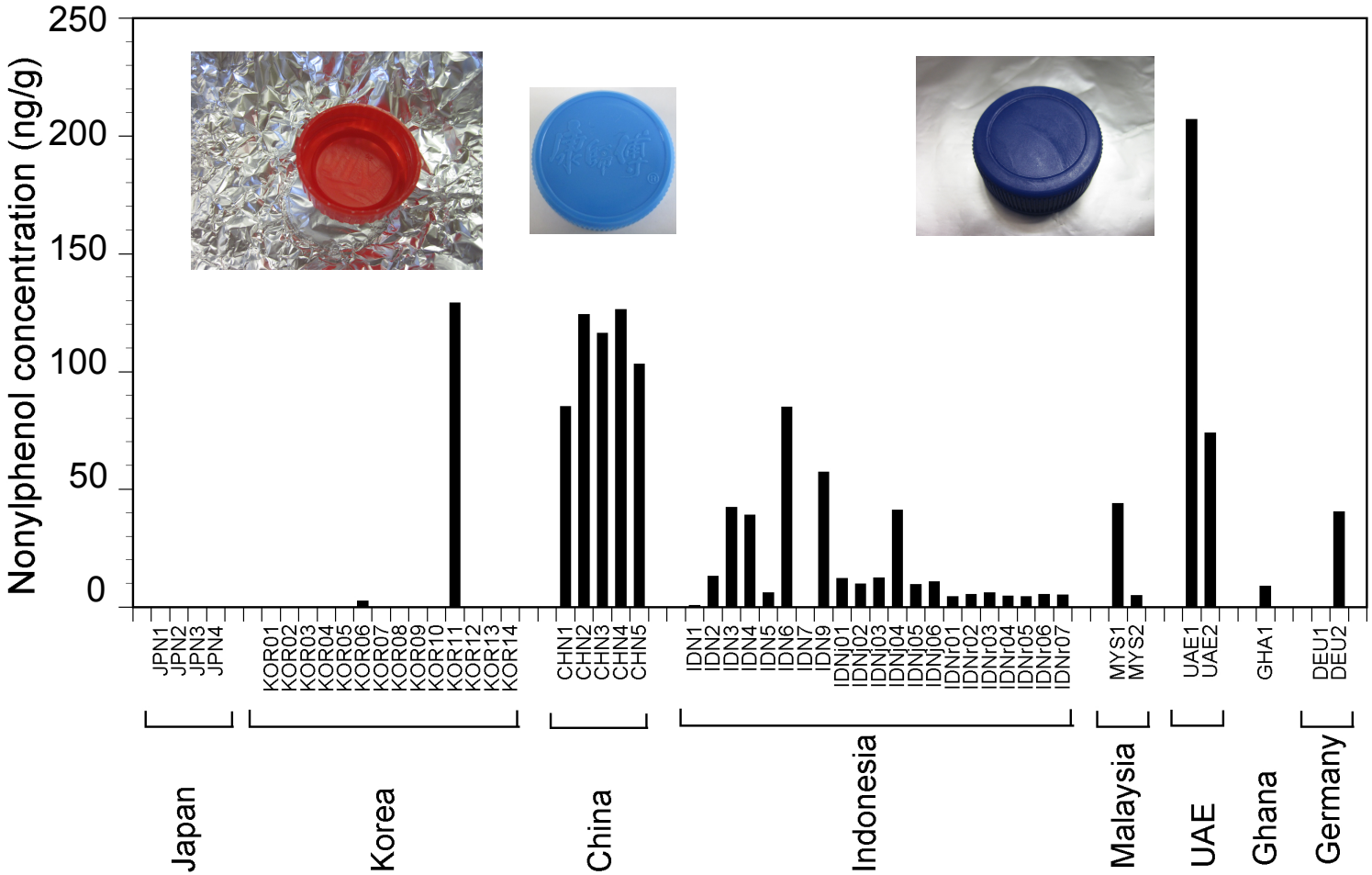


Nonylphenols leached from plastic products



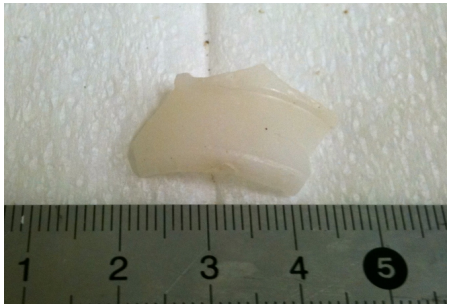
Nonylphenols are still leached from imported plastic products

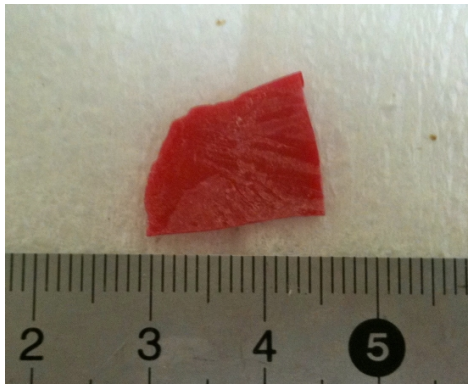
World Cap 2012
nonylphenols leached from screw cap of bottled water

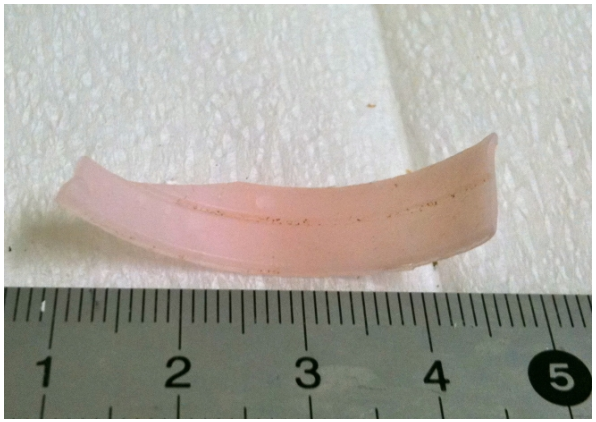


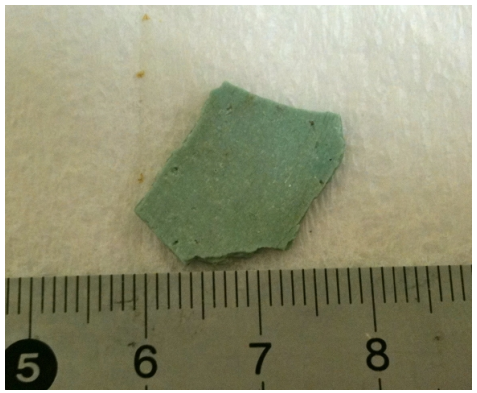
Sampling locations of user plastic fragments

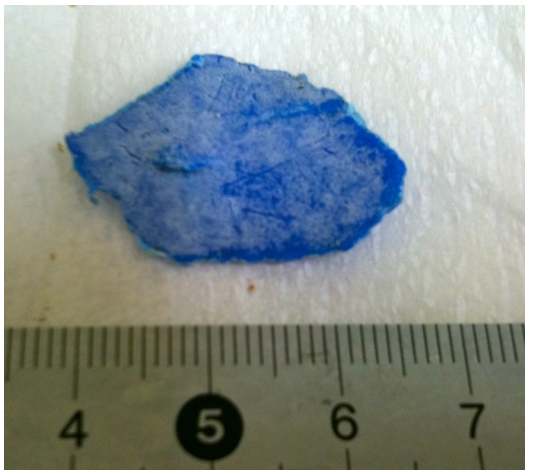
Examples of analyzed plastic fragments



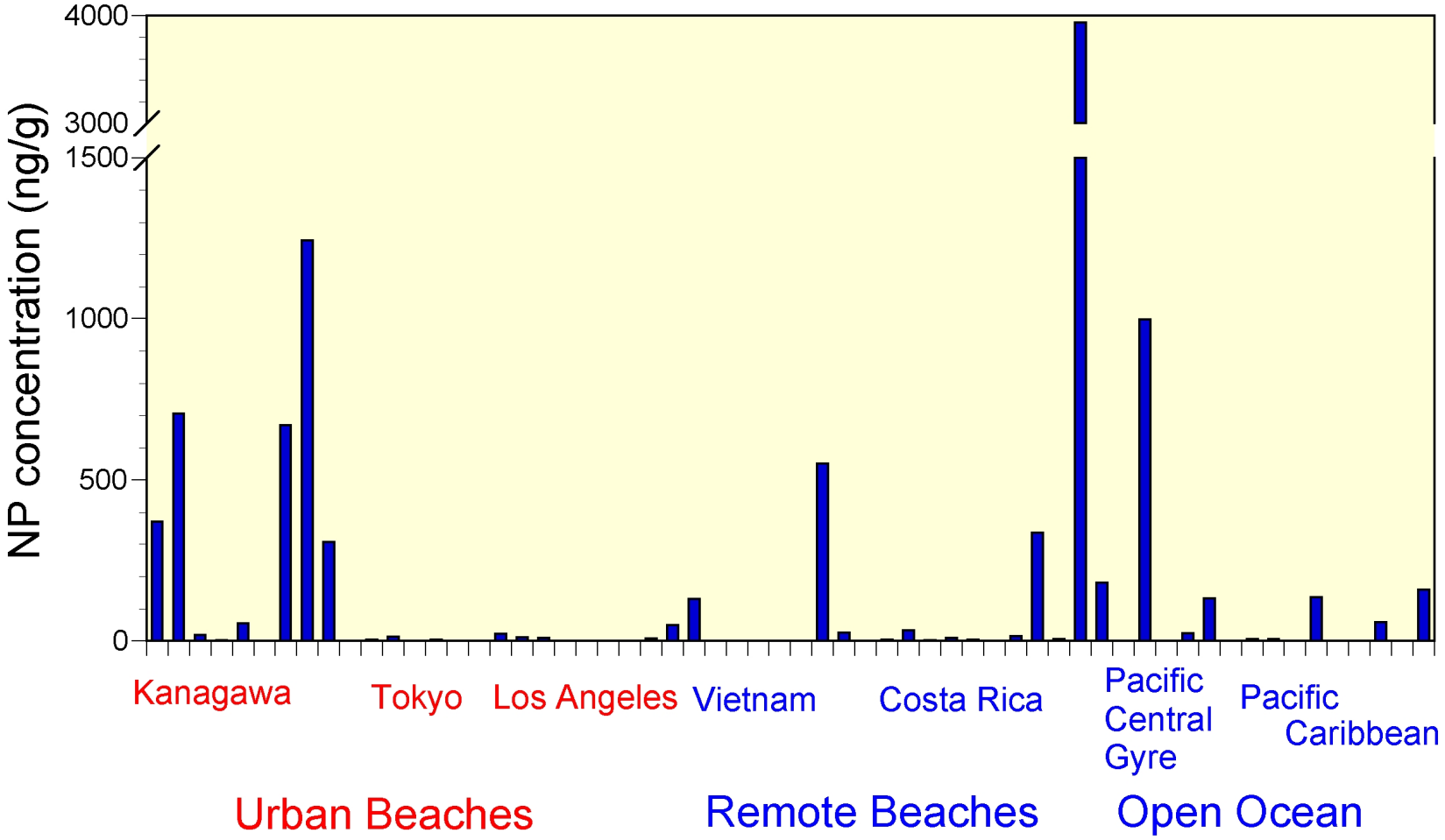






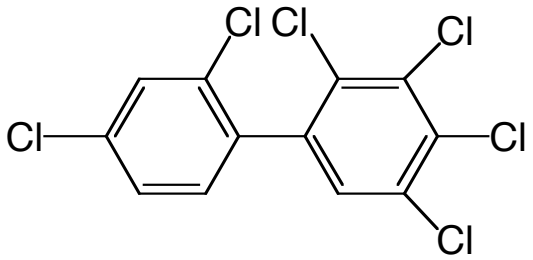


Distribution of Nonylphenols in plastic fragments

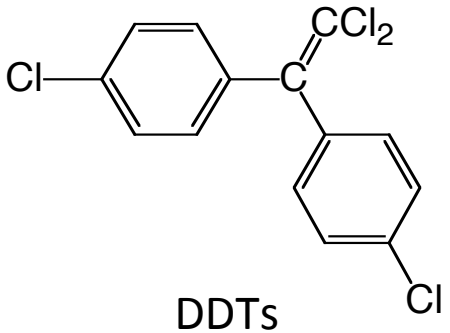


Marine plastics carry two types of chemicals

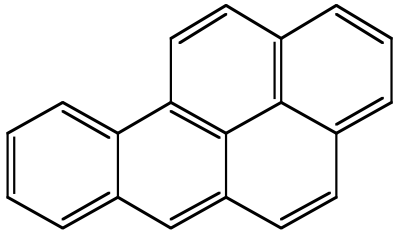
Sorption from ambient seawater



Polychlorinated biphenyl (PCBs)

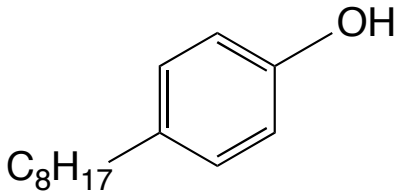


DDTs

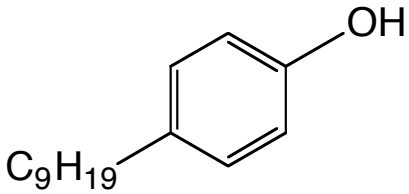


Polycyclic aromatic hydrocarbons (PAHs)

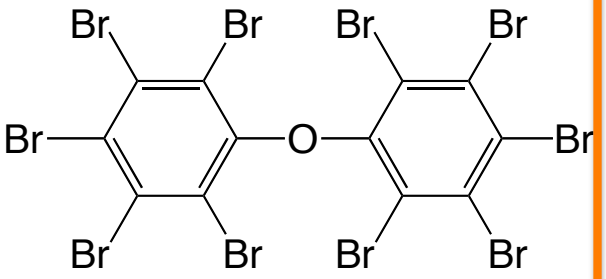
Additive-derived chemicals



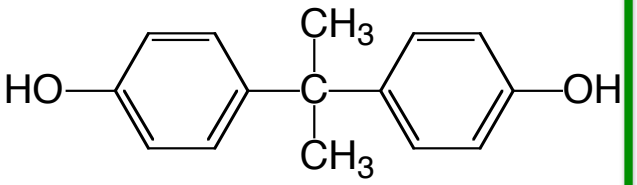
Octylphenol



Nonylphenol



Polybrominated diphenyl ethers (PBDEs)

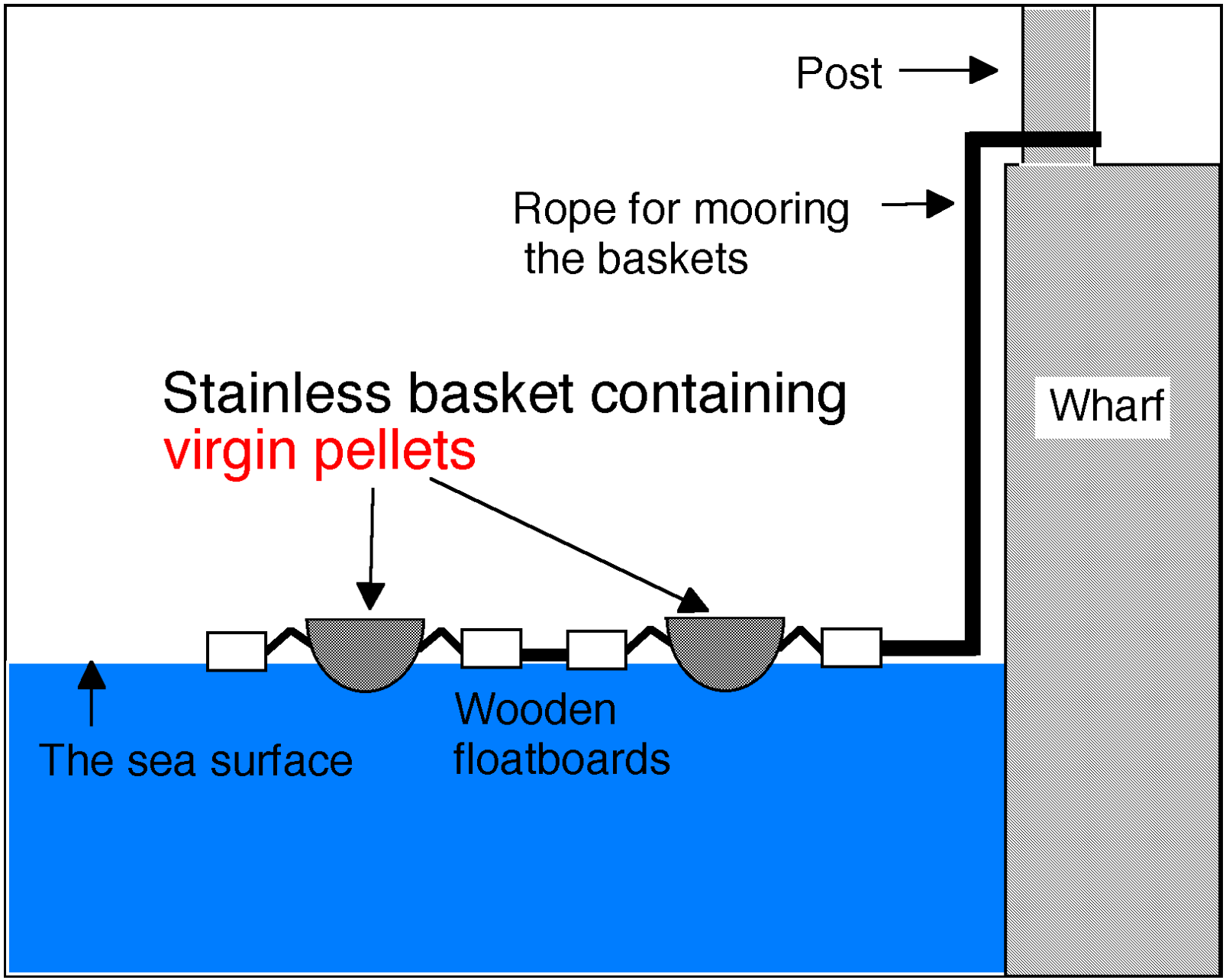


Bisphenol A

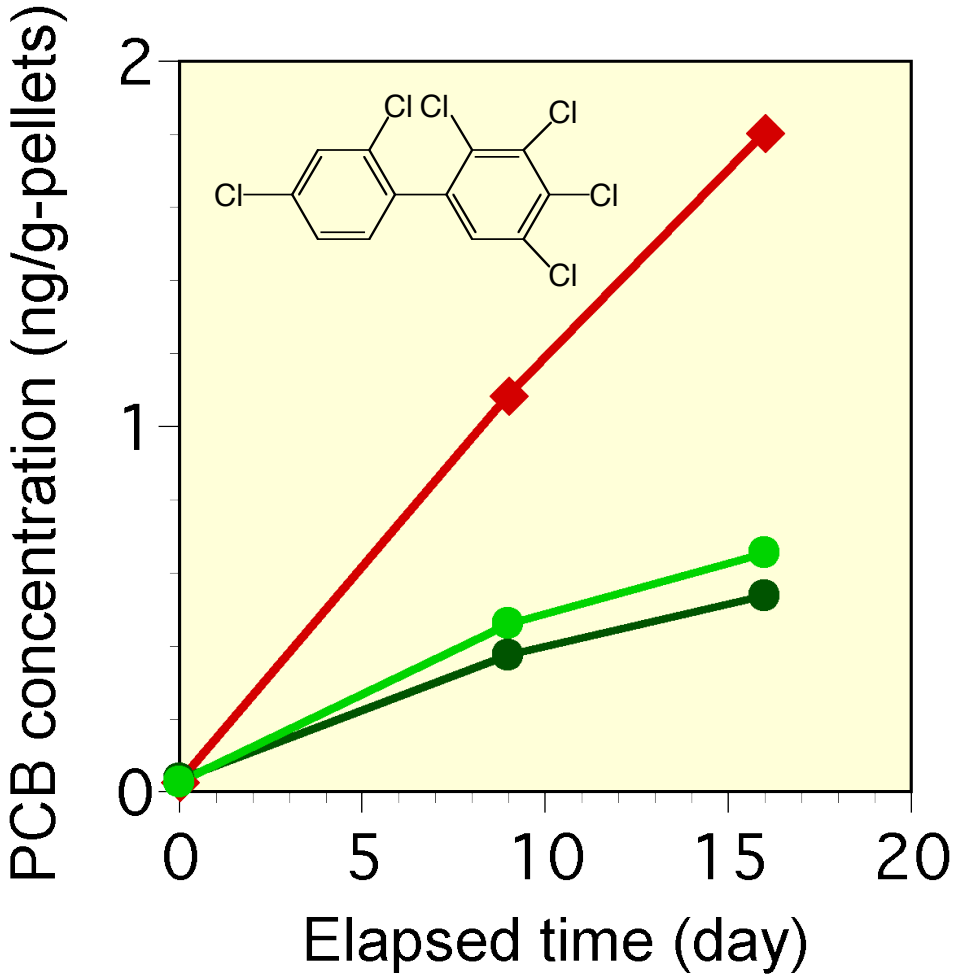
Plastic Resin Pellets as a Transport Medium for Toxic Chemicals in the Marine Environment

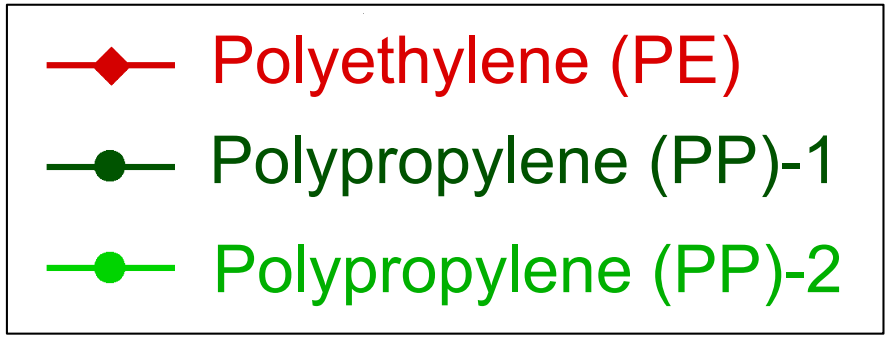
Environmental Science & Technology
2001, vol.35, 318-324

Schematic illustration of **adsorption experiment**



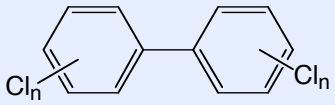
Adsorption of PCBs onto marine plastics





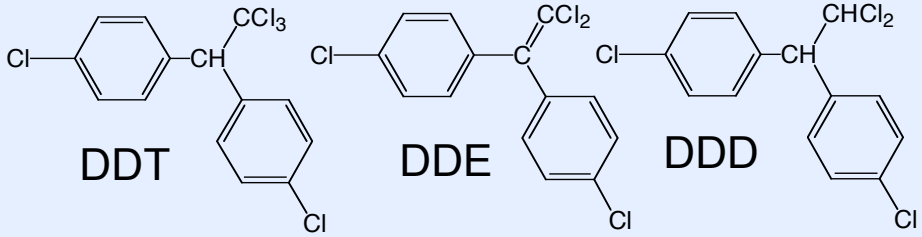
Persistent organic pollutants (POPs)

PCBs



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

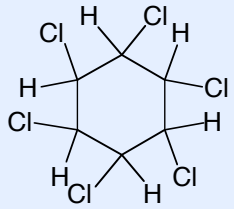
DDTs



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

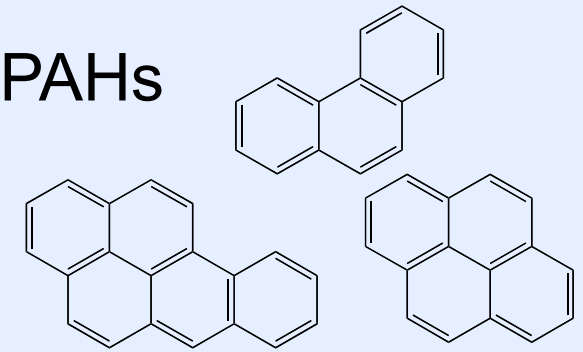
- ✓Man-made chemicals
- ✓Persistent (stable, resistant to degradation)
- ✓Toxic to human and marine organisms
- ✓Hydrophobic (lipophilic)

HCH



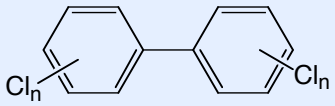
- Insecticide

PAHs



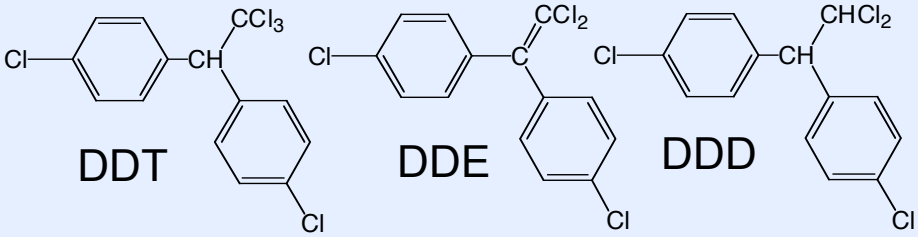
Plastics accumulate organic pollutants from seawater

PCBs



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

DDTs

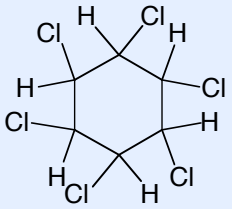


- DDT and its metabolites such as DDE and DDD.
- DDT was used as insecticides
- Endocrine disrupting chemicals

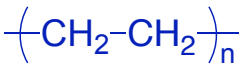
adsorption from ambient seawater

Plastics

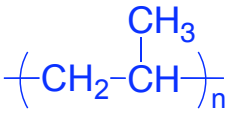
HCH



- Insecticide

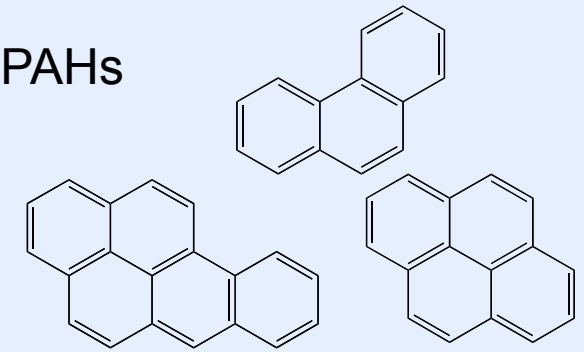


Polyethylene (PE)



Polyprorylene (PP)

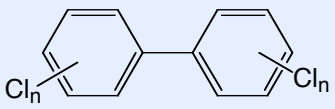
PAHs



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

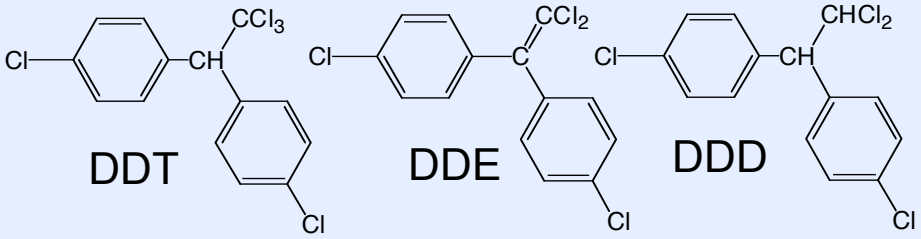
Pellets accumulate POPs from seawater

PCBs



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

DDTs

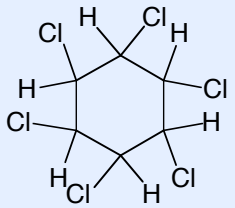


- DDT and its metabolites such as DDE and DDD.
- DDT was used as insecticides
- Endocrine disrupting chemicals

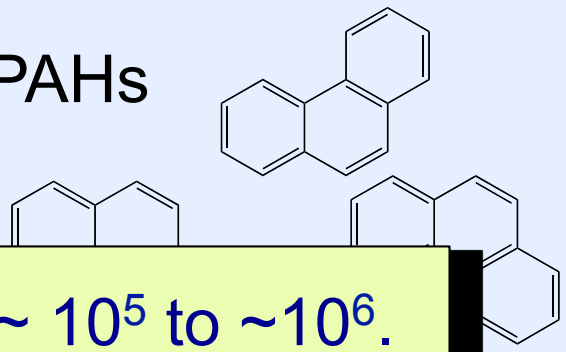
adsorption from ambient seawater

Plastics

HCH

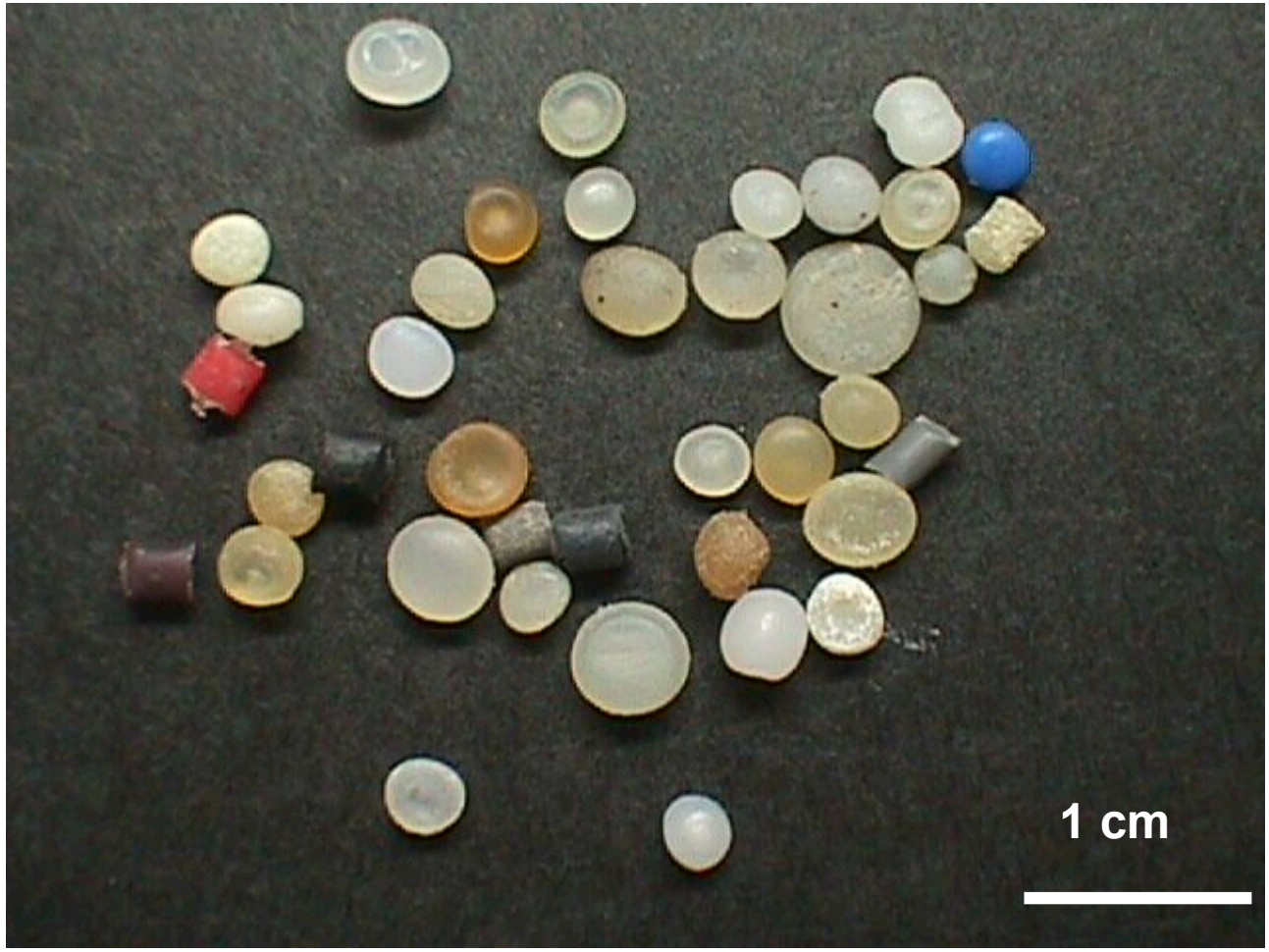


PAHs



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

Plastic Resin Pellets

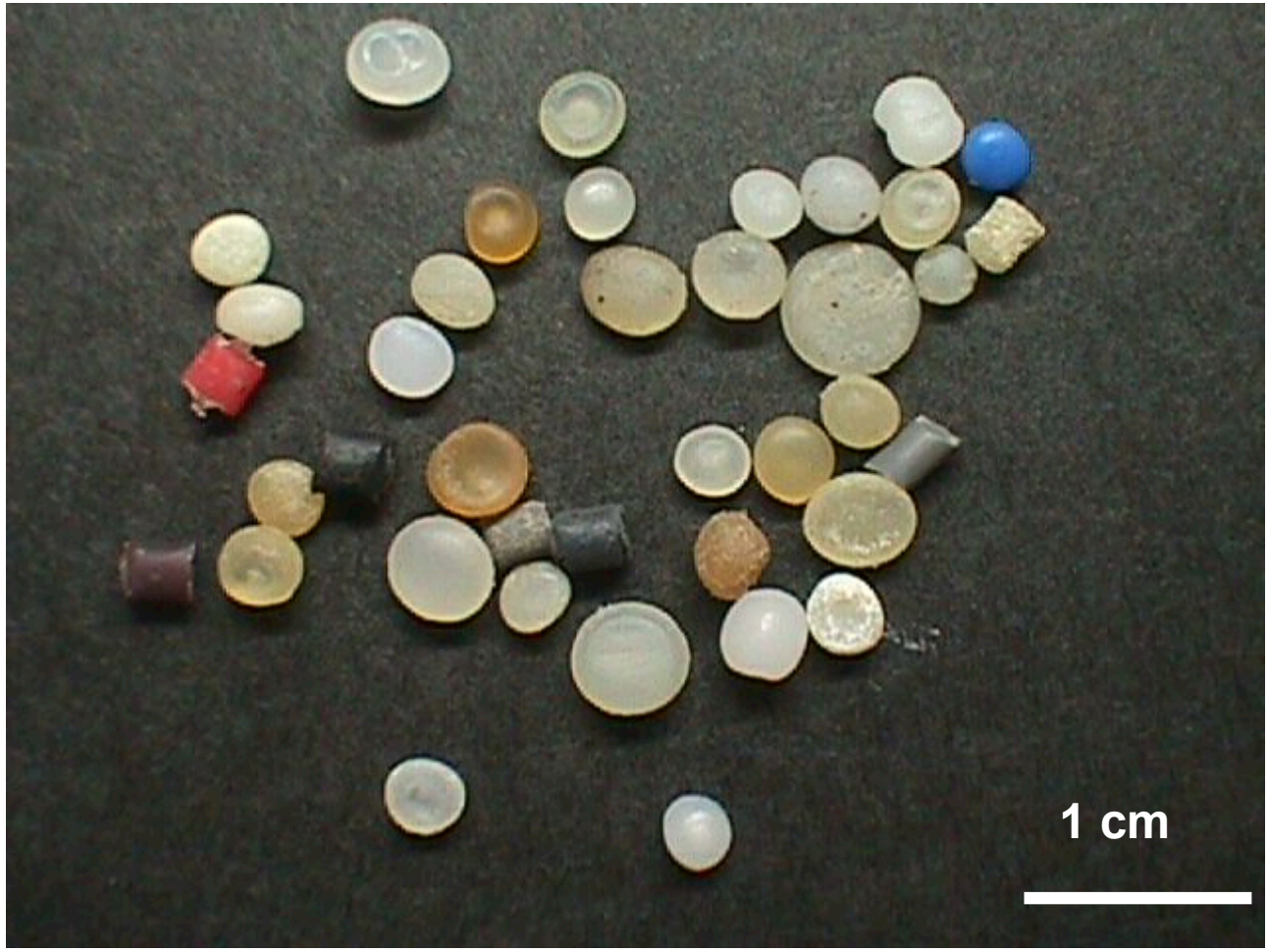


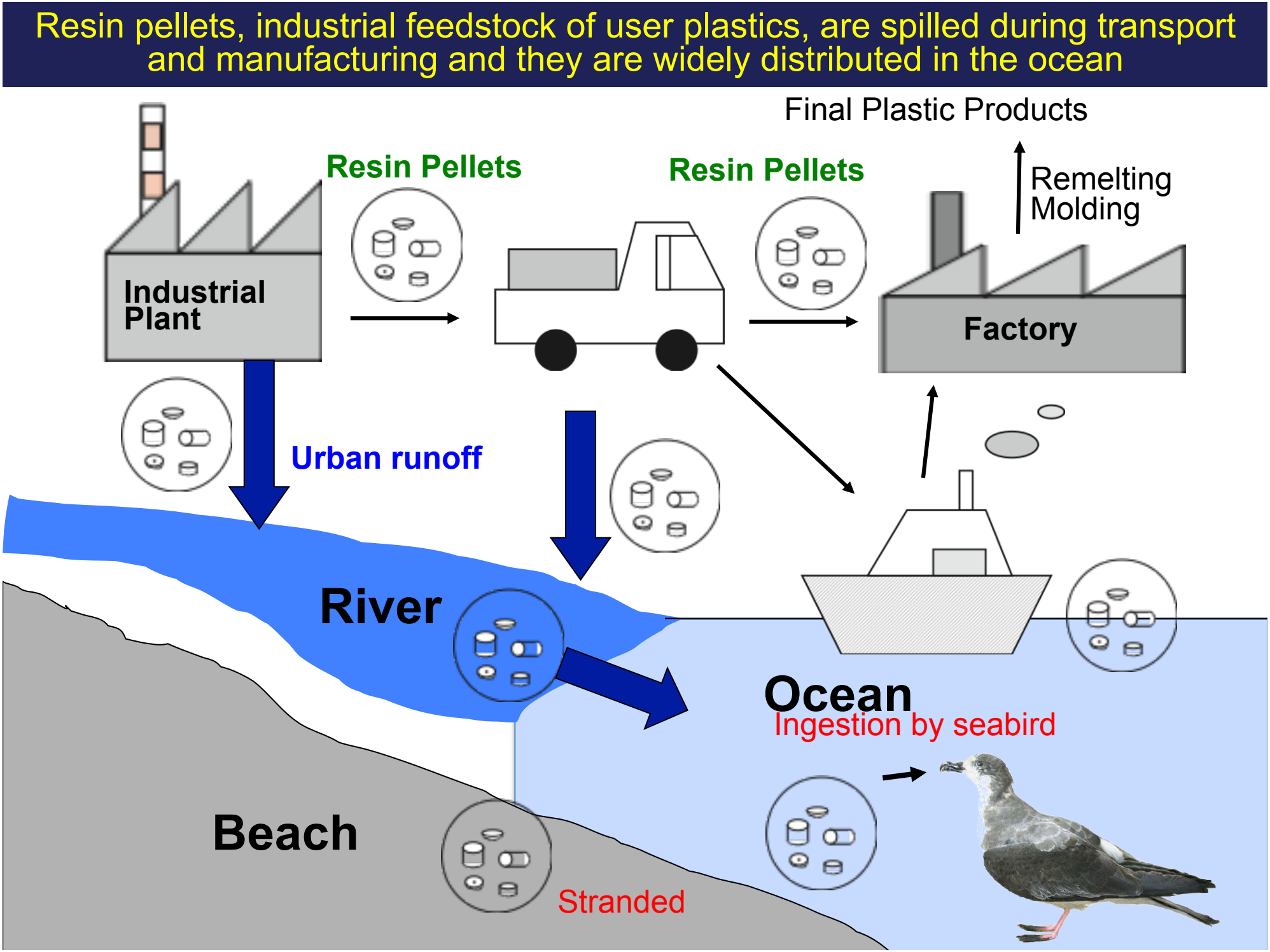
Trashes on high-tide line on our beaches

Trashes on high-tide line on our beaches

Trashes on high-tide line on our beaches

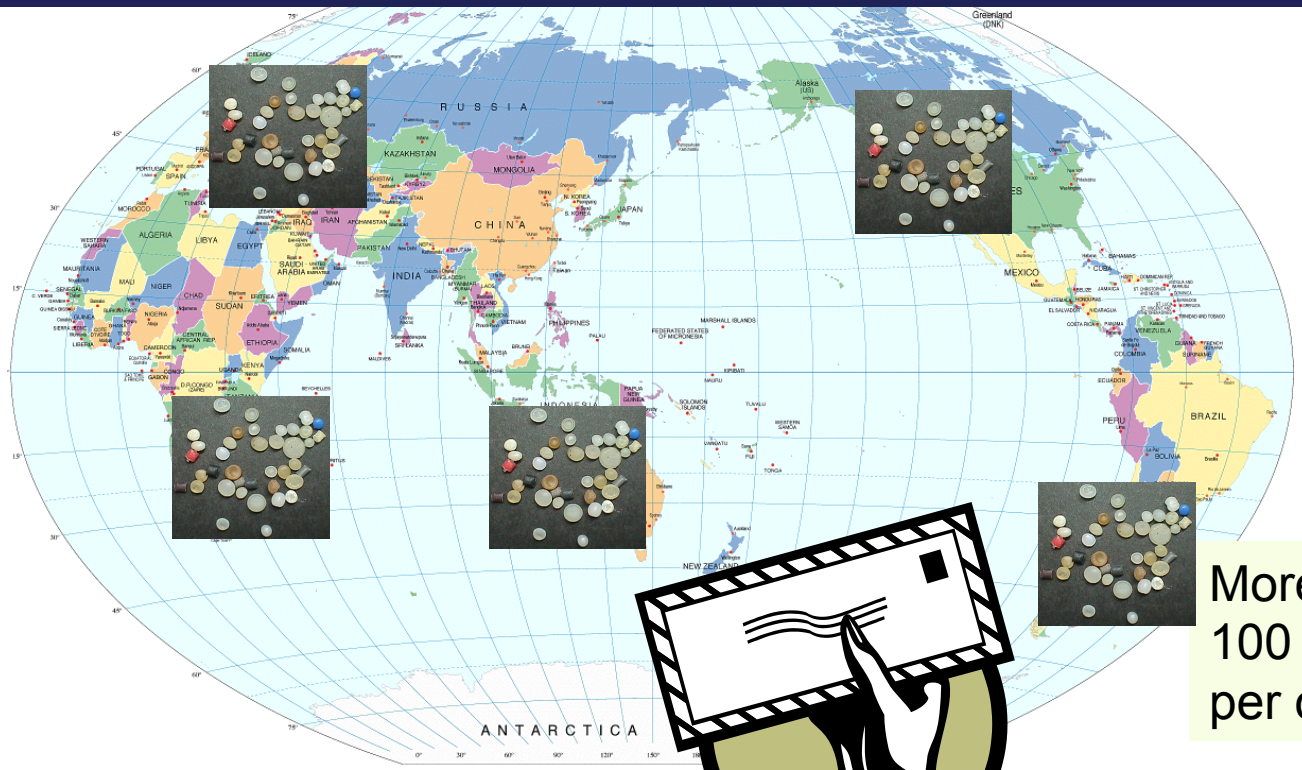
Plastic Resin Pellets




Resin pellets, industrial feedstock of user plastics, are spilled during transport and manufacturing and they are widely distributed in the ocean
Final Plastic Products
Resin Pellets
Resin Pellets
Remelting
Molding
Industrial Plant
Factory
Urban runoff
River
Ocean
Ingestion by seabird
Beach
Stranded

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**


CSIR
WNNR
Dr Hideshige Takada,
Laboratory of Organic Chemistry
Institute of Symbiotic Science and Technology,
Tokyo University of Agriculture and Technology,
7-5-8 Saiwaicho
Fuchu
Tokyo 183-8509
JAPAN
Dr Hideshige TAKADA
Laboratory of Organic Geochemistry
Tokyo University of Agriculture
and Technology
Fuchu, Tokyo 183-8509
JAPAN
Miriam Gorden
California Coastal Commission
45 Fremont St, Stezoore
SF, CA 94105
$2.75
Laboratory of Organic Geoch. Hstry
Dr. Hideshige Takada
Tokyo University of Agriculture
Technology
Fuchu, Tokyo 183-509
JAPAN
PAR AVION
AIR MAIL
Port Townsend
Marine Science Center
$0.90
Laboratory of Organic Geochemistry
Dr. Hideshige TAKADA
Tokyo University of Agriculture and Technology
Fuchu, Tokyo 183-8509
JAPAN
PAR AVION
AIRMAIL
Dr Hideshige Takada
Laboratory of Organic Geochemistry,
Tokyo University of Agriculture and Technology,
Fuchu,
Tokyo 183-8509,
Japan

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

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

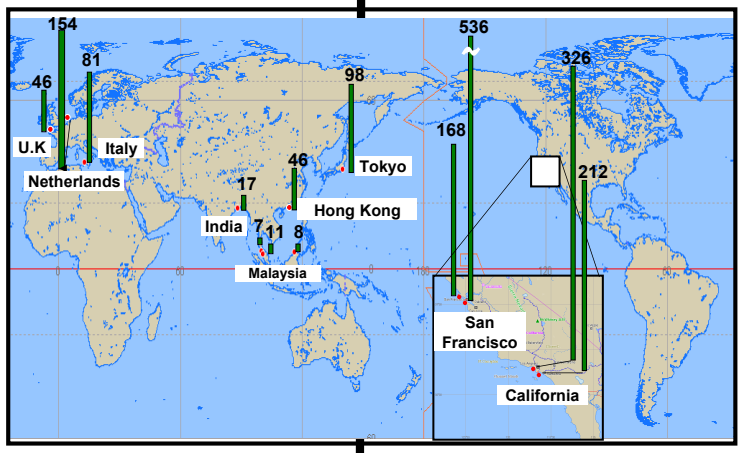
Sorting

PE, yellowing pellets

Analysis for POPs (PCBs, organochlorines, PAHs)

By GC-MS/MS, GC-MS, GC-ECD
more than 5 pools of 5 pellets
to exclude sporadic high concentration

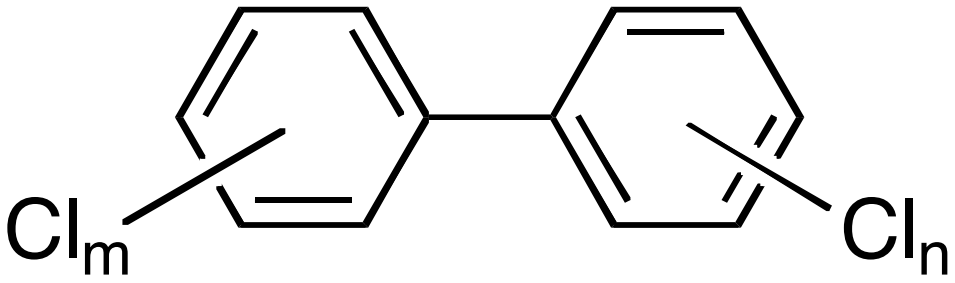
Mapping POPs pollution



- **Sending the data** via Internet to the collaborators
- **Releasing** the results on **web**

~200 locations from 40 countries

Polychlorinated biphenyls (PCBs)



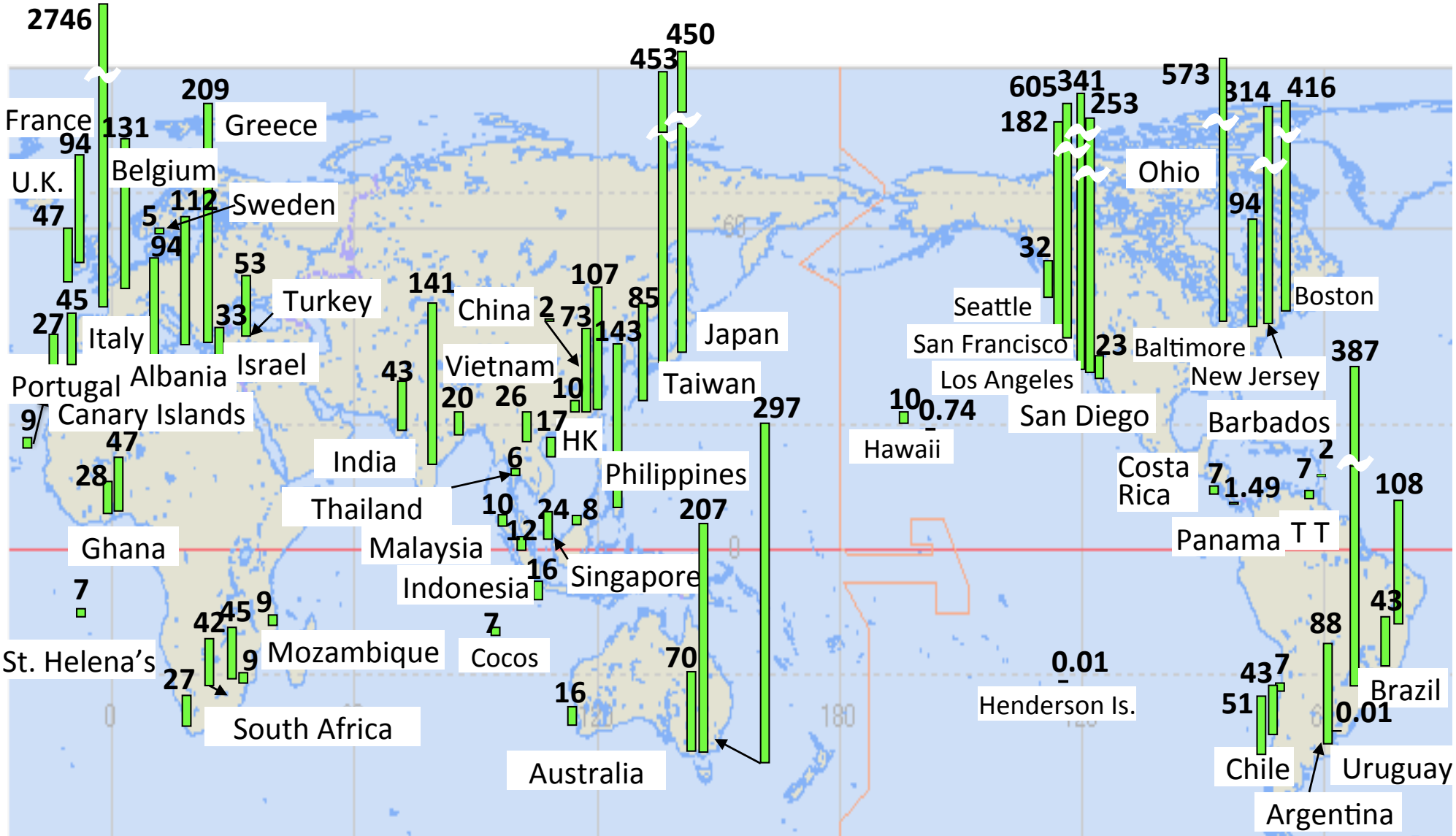
$m + n = 1 - 10$

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



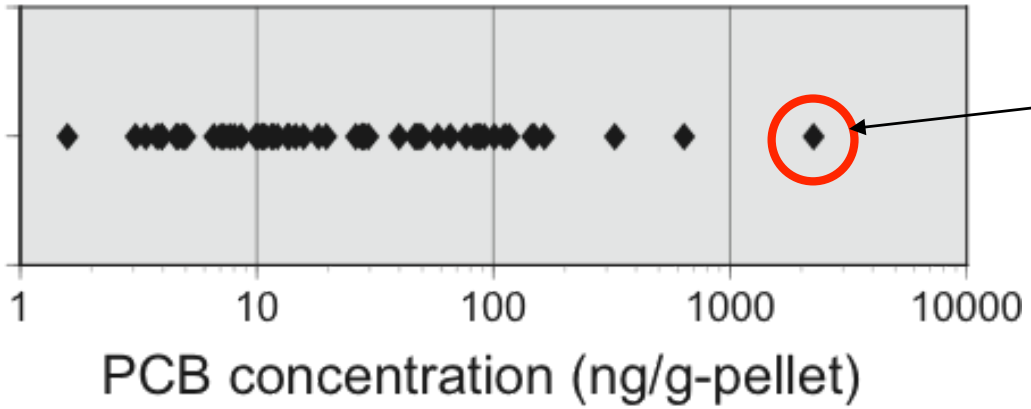
Concentration of PCBs* in beached plastic resin pellet (ng/g-pellet)

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

To minimize the effects of piece-to-piece variation and to get areal representative values, 5 pools of yellowing PE pellets are analyzed and median concentrations are used.

Sorting

Polyethylene (PE)
Yellowing

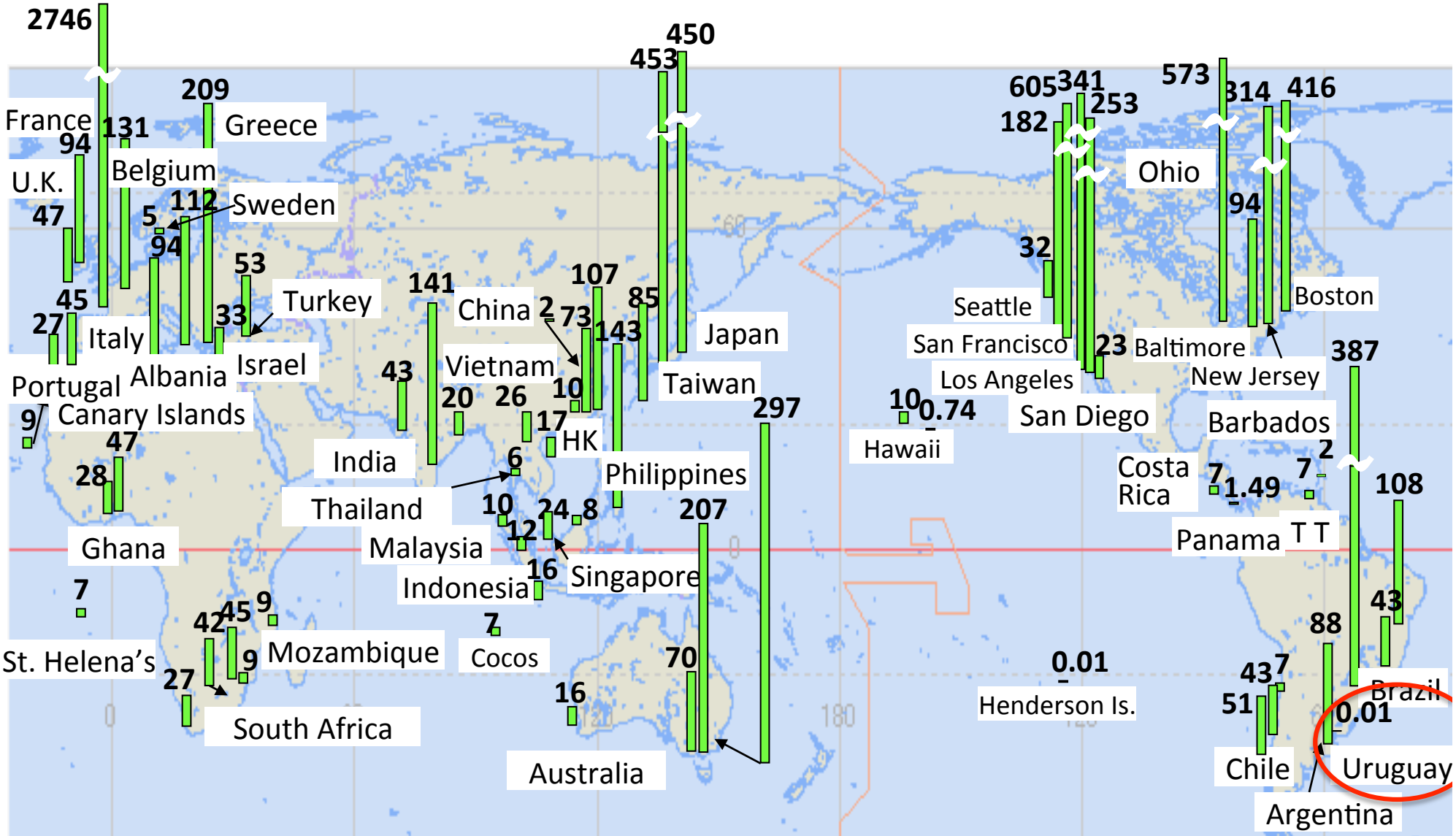


(Endo et al., 2005)

To exclude sporadic high concentrations of PCBs

Multiple 10-pellet pools are analyzed for PCBs

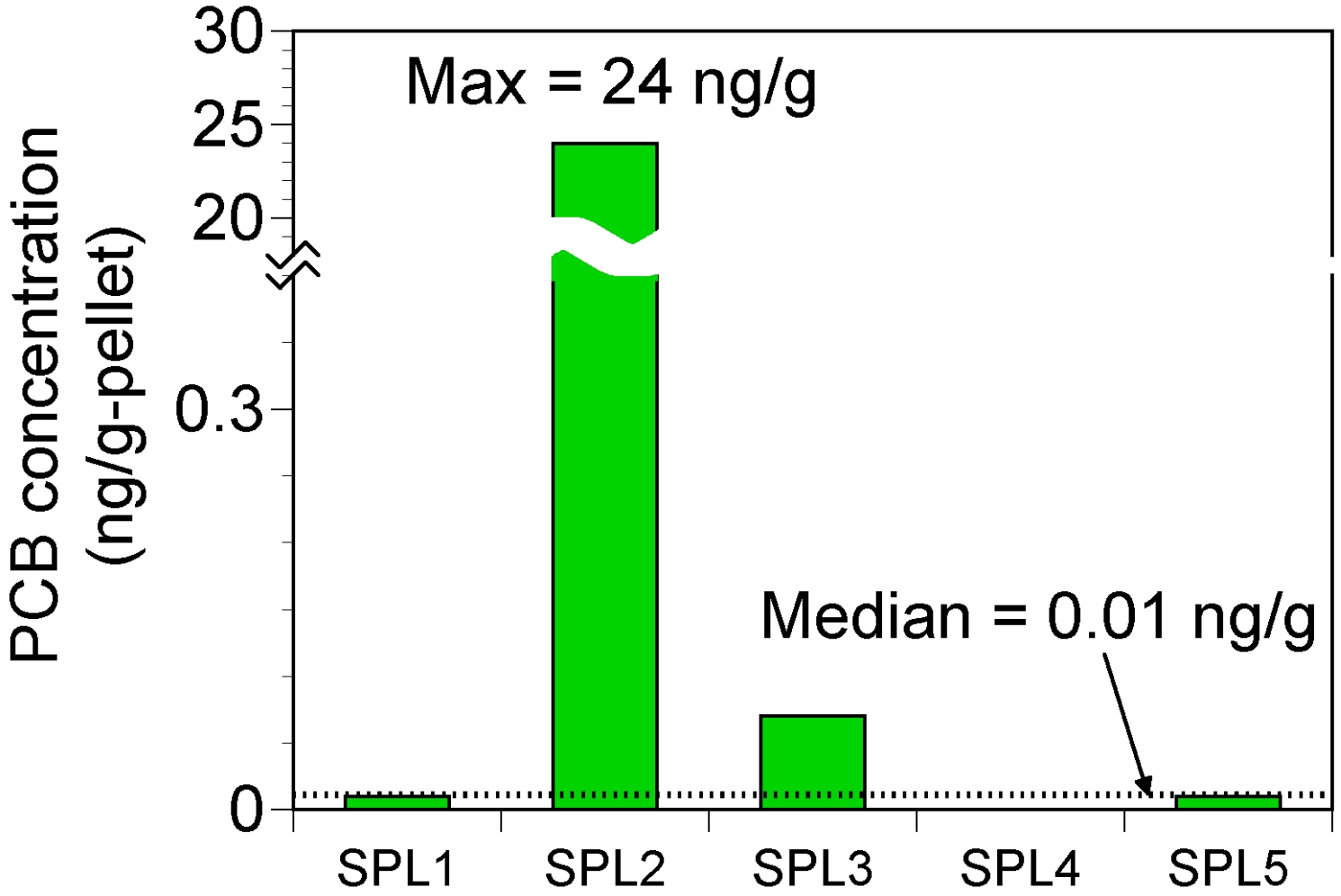
Median concentrations

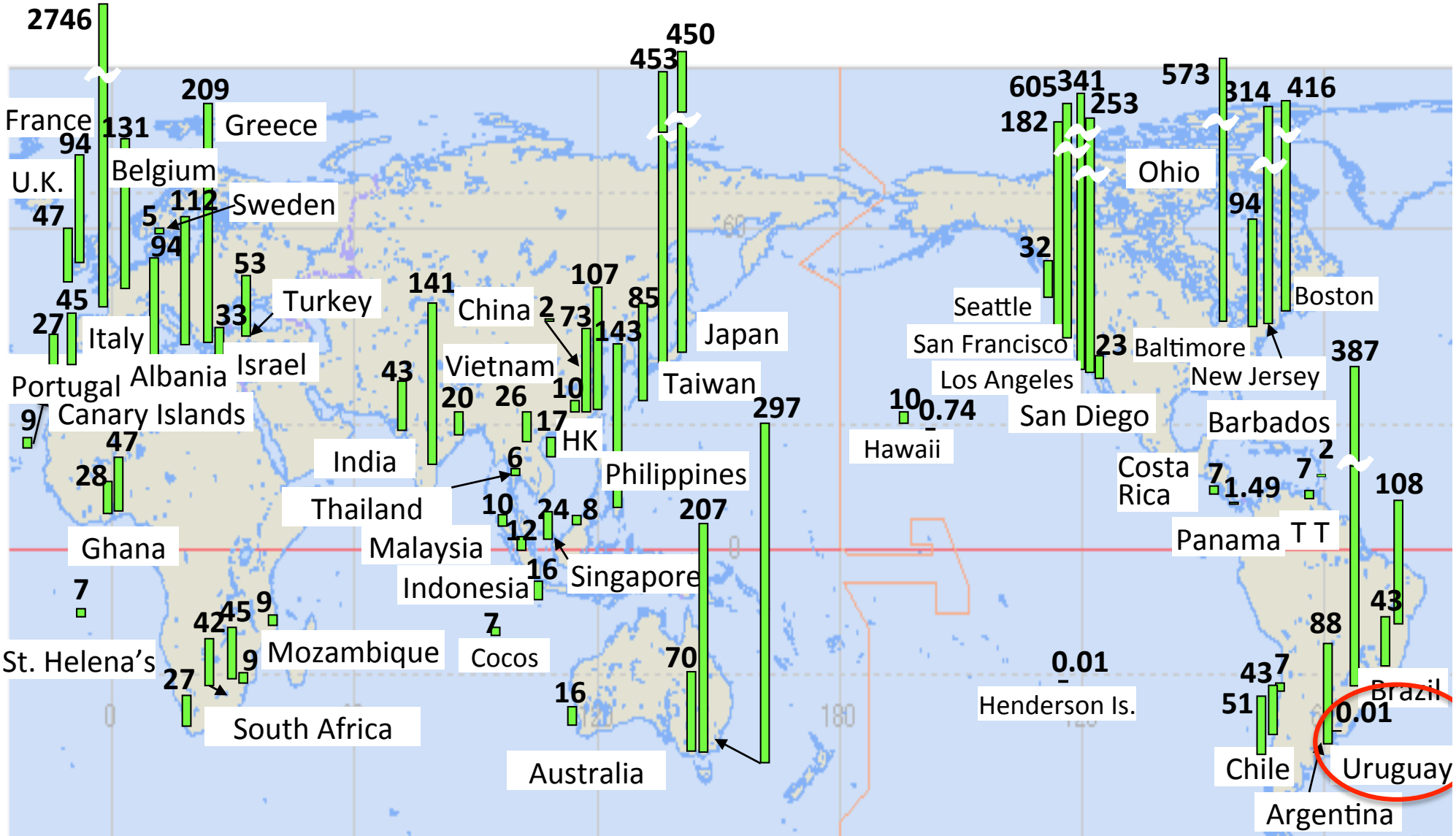


Concentration of PCBs* in beached plastic resin pellet (ng/g-pellet)

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

Sporadic high concentrations of POPs are often observed in pellets from remote beaches

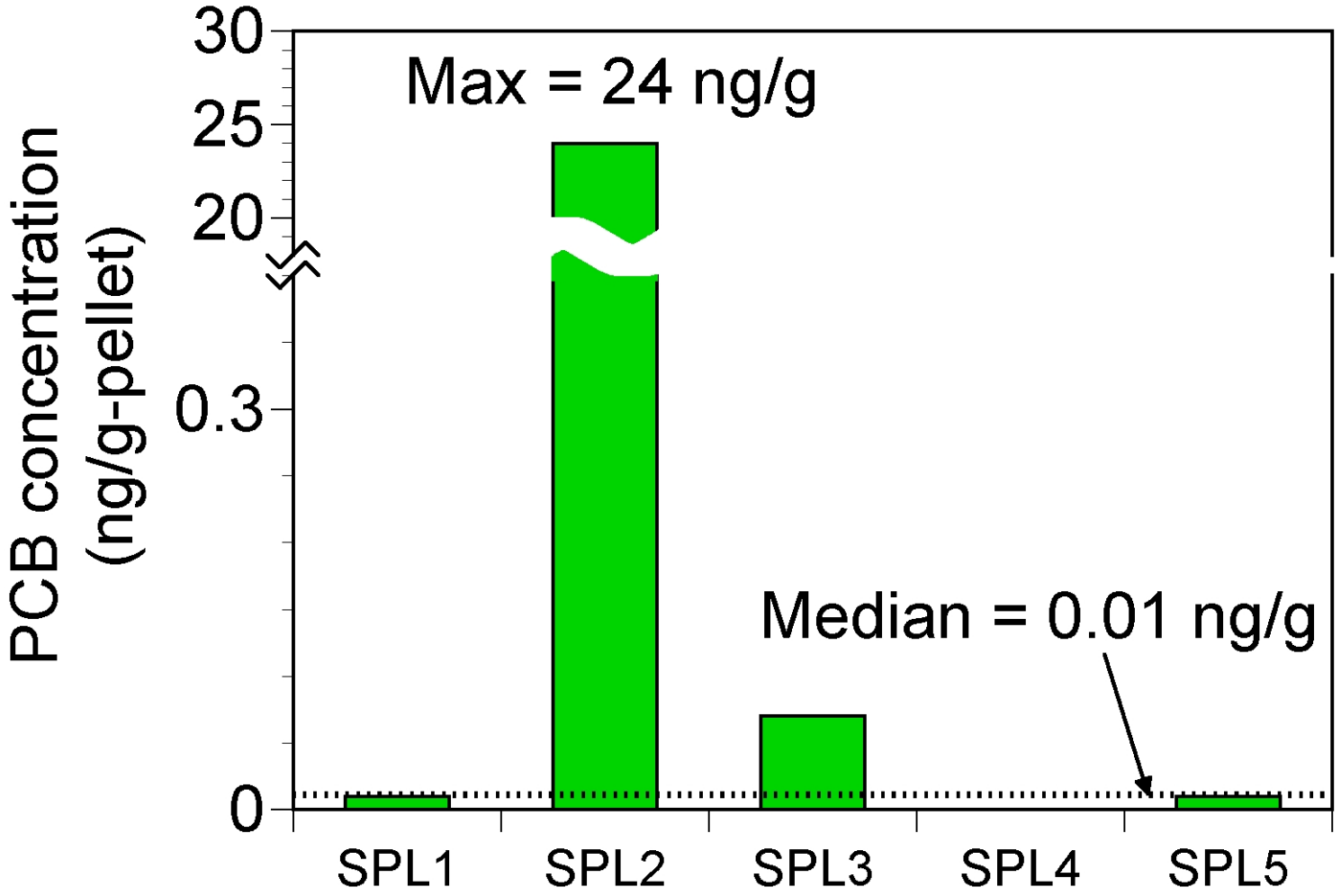




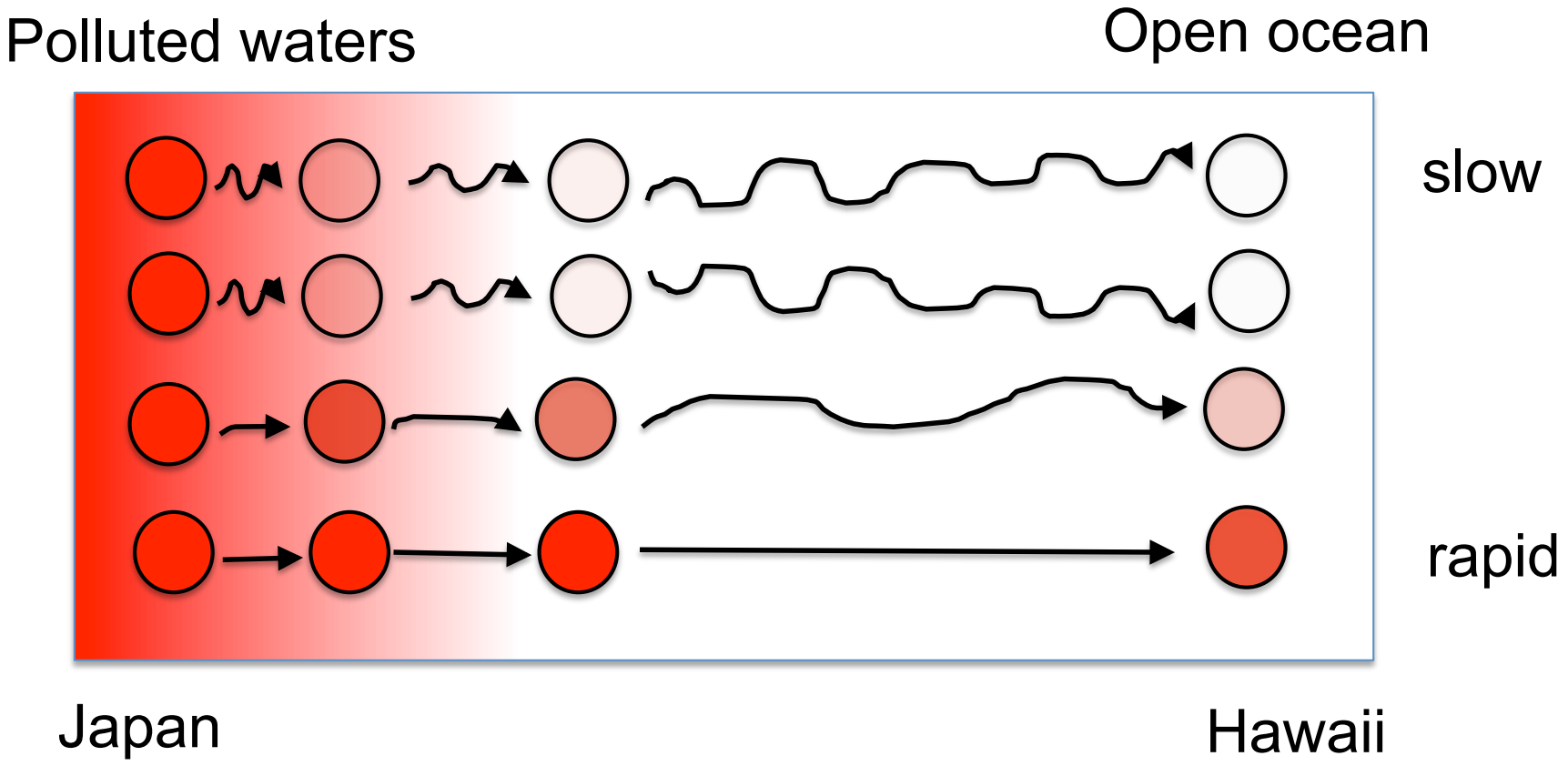
Concentration of PCBs* in beached plastic resin pellet (ng/g-pellet)

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

Sporadic high concentrations of POPs are often observed in pellets from remote beaches



Slow desorption and fast transport may cause sporadic high concentration of PCBs in plastic from open ocean

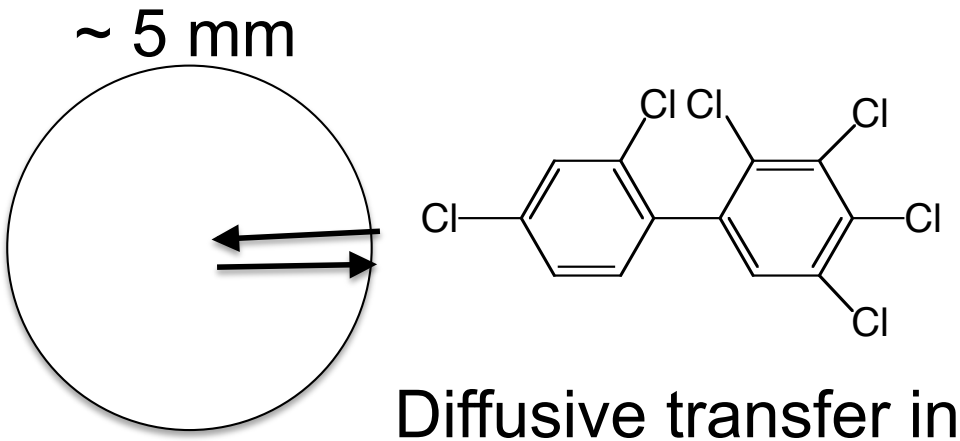


Different speed/route of transport

Non-equilibrium : slow sorption/desorption

➡ Sporadic high concentrations of PCBs were detected even in remote beaches and open ocean

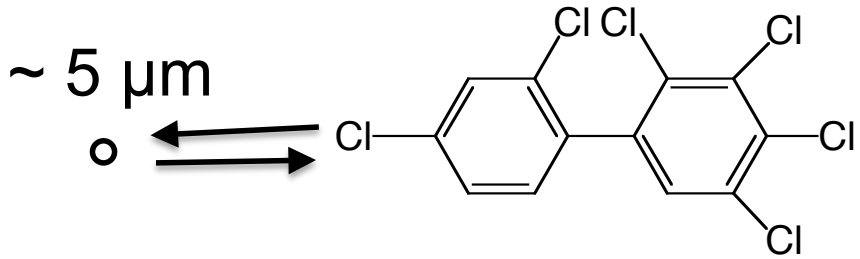
Larger diameters and slow diffusive transport cause non-equilibrium



Diffusive transfer in plastic matrix

Plastic fragment/pellet with 3 mm diameter

Long time (~ 1 year) to reach equilibrium

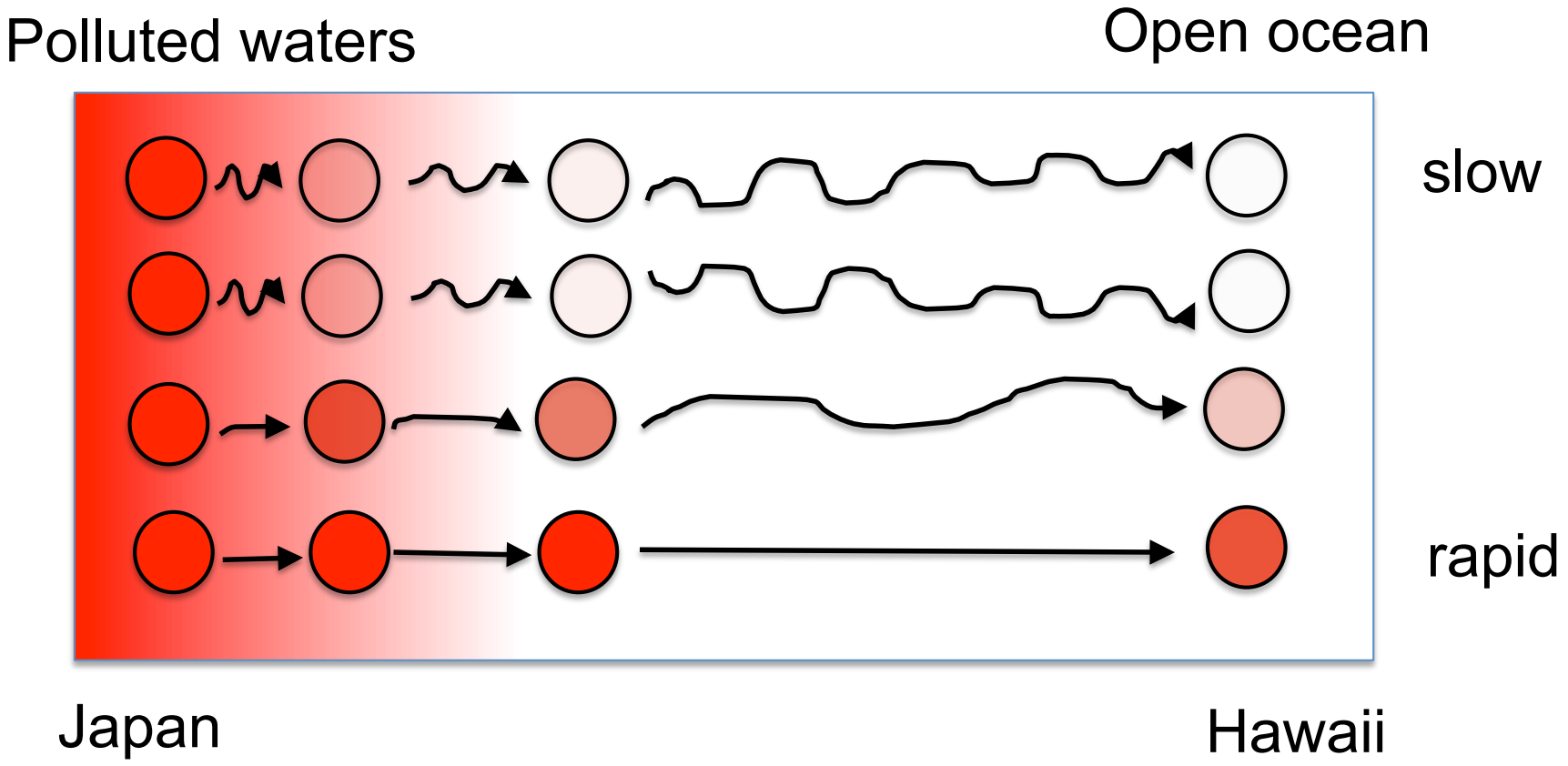


surface process

Conventional vector : sediment particle with a few µm

Fast (~ hours) to reach equilibrium

Slow desorption and fast transport may cause sporadic high concentration of PCBs in plastic from open ocean



Different speed/route of transport

Non-equilibrium : slow sorption/desorption

➡ Sporadic high concentrations of PCBs were detected even in remote beaches and open ocean

Unique characters of marine plastics as transport media of organic micropollutants

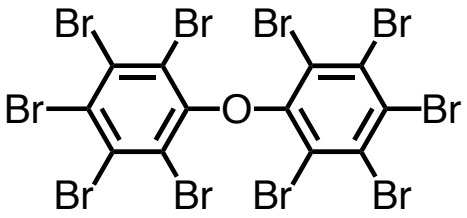
- ✓ Slow sorption/desorption and sporadic high concentrations of pollutants

- ✓ Additive-derived chemicals

Previous assessment missed these characters.

⇨ Marine plastics carry toxic chemicals to remote ecosystem

Detection of polybrominated diphenyl ethers (PBDEs) in tissue of seabird ingesting plastics

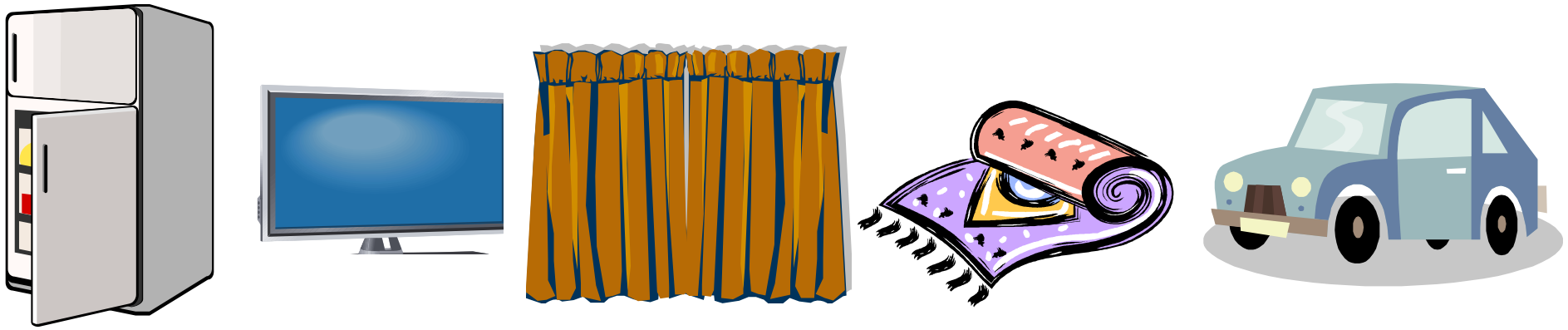


Short-tailed shearwater
Puffinus

We got the evidence to the transfer,
though it has not yet published

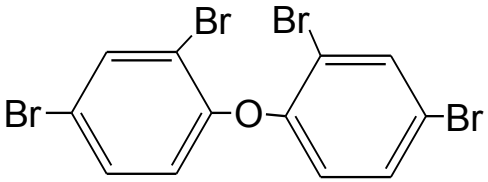
PBDEs : Flame retardants

applied in various electric products and fabrics.



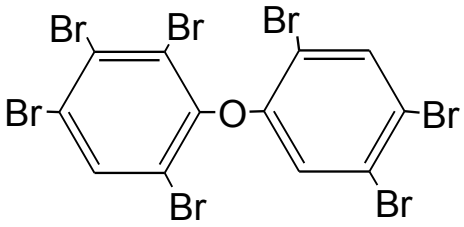
3 technical products (mixtures of congeners)

Penta BDE
(Br4, Br5)



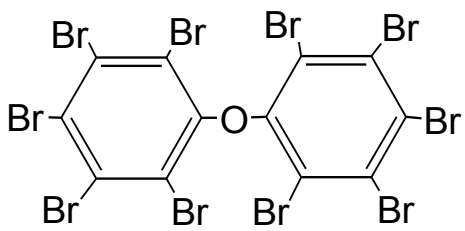
e.g., BDE47

Octa BDE
(Br7,8)



e.g., BDE183

DecaBDE
(Br10)



e.g., BDE209

Conclusions

Marine plastics contain various toxic chemicals including additives and POPs sorbed from surrounding seawater.

Marine plastics carry toxic chemicals
to remote ecosystem

Transfer of the chemicals from plastics to internal tissue of seabirds which ingest marine plastics was strongly suggested.